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ONE-HUNDRED-AND-THIRTY-SIXTH SESSION, 1889-90.

COUNCIL.

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H. Trueman Wood, M.A.

ASSISTANT SECRETARY.	*ACCOUNTANT.*	*AUDITOR.*
Henry B. Wheatley, F.S.A.	Howard H. Room.	J. Oldfield Chadwick, F C.A.

SESSIONAL ARRANGEMENTS.

The First Meeting of the One Hundred and Thirty-sixth Session of the Society was held on Wednesday, the 20th November, when the Opening Address by The Duke of Abercorn, C.B., Chairman of the Council, was, in his unavoidable absence, delivered by Sir Frederick Bramwell, Bart., D.C.L., F.R.S., Deputy-Chairman. Previous to Christmas there will be four Ordinary Meetings, in addition to the Opening Meeting. The following arrangements have been made :—

November 27.—J. Hall Gladstone, Ph.D., F.R.S., "Scientific and Technical Instruction in Elementary Schools." The Right Hon. A. J. Mundella, M.P., in the chair.

December 4.—Armand Ruffer, M.A., M.D., "Rabies and its Prevention." Sir Joseph Lister, Bart., F.R.S., D.C.L., LL.D., in the chair.

" 11.—H. Trueman Wood, M.A., Secretary to the Society, "The Paris Exhibition." Sir Philip Cunliffe-Owen, K.C.B., K.C.M.G., C.I.E., in the chair.

18.—Sir Robert Rawlinson, K.C.B., "London Sewage."

For meetings after Christmas:—

SIR DOUGLAS GALTON, K.C.B., D.C.L., F.R.S., "The Chemin de Fer Glissant, or Sliding Railway."
GEORGE FINDLAY, General Manager London and North-Western Railway, "Modern Improvements in Facilities for Railway Travelling."
J. S. KELTIE, "Commercial Geography."
E. C. ROBINS, "The Relation of the Fine Arts to the Applied Arts."
J. HENNIKER HEATON, M.P., "Ocean Penny Postage and Cheap Telegraph Communication between England and all Parts of the Empire and America."
A. LASENBY LIBERTY, "The Industrial Arts of Japan."
FREDERICK C. DANVERS, "The Records of the India-office."
J. TRIPPLIN, "Recent Progress in British Watch and Clock Making."
C. G. WARNFORD LOCK, "Gold Mining in Hungary."

FOREIGN AND COLONIAL SECTION.

The meetings of this Section will take place on the following Tuesdays, at Five o'clock:—

January 21; February 18; March 18; April 22; May 6, 20.

INDIAN SECTION.

The meetings of this Section will take place on the following Fridays, at Five o'clock:—

January 17; February 7, 28; March 14; April 18; May 16.

APPLIED ART SECTION.

The meetings of this Section will take place on the following Tuesday evenings, at Eight o'clock:—

January 28; February 11; March 4, 25; April 15; May 13.

CANTOR LECTURES.

These Lectures are delivered on Monday evenings, at Eight o'clock:—

The First Course will be on "Modern Developments of Bread Making." By WILLIAM JAGO, F.C.S., F.I.C. Four Lectures.

LECTURE I.—NOVEMBER 25.—*Introduction—Selection of Flours.*—Outline description of bread-making processes.—Ferments,—Sponges.—Doughs.—First step of successful bread-making.—Choice of flour.—Classification of flours according to wheats.—Single *versus* mixed wheat flours.—Advantages of each course to miller and baker respectively.—General properties of flours from English, spring and winter American, Canadian, Russian, Hungarian, Indian, and other wheats, illustrated by samples of flour and bread.—Comparison between roller-milled and stone-ground flours.—Principles governing the blending of flours for sponges and doughs respectively.—Commercial modes of flour testing.—Bread yield of flours.—Relation to per-centage of moisture present.—Per-centage of gluten in flour.—Relation to lightness and size of loaf.—Colour estimation and registration.—Flavour of flours.—Baking tests.

LECTURE II.—DECEMBER 2.—*Yeast and Fermentation.*—Yeast, nature of, and functions in bread-making.—Aëration.—Action on albuminous matters.—Brewers' and bakers' patent yeasts largely replaced by compressed distillers' yeast.—Properties of each variety, including effects on colour, flavour, volume, &c., of the bread.—Relative strength or fermenting power of each.—Foreign and British condensed yeast factories.—Future development of British yeast trade.—Bearing of Hansen's researches on pure yeast cultivation on bread-making.—Salamon's Cantor lectures on "Yeast."—Properties required to produce a perfect bakers' yeast.—Outline of yeast-testing.—Microscopic examination.—Determination of strength.—Yeast adulteration.—Conditions which affect the behaviour of yeast in dough.—Sour bread, causes and remedies.

LECTURE III.—DECEMBER 9.—*Bread Factories and Mechanical Appliances.*—Requirements in a perfect bread factory or modern bakehouse.—Sanitary arrangements.—Provisions for the control of temperature, and other details.—Examples of bakeries on modern lines.—Mechanical appliances.—Flour-blending machines.—Flour-sifting machines.—Dough-kneading machinery, various types.—Water-gauging and attemperating appliances.—Dough-dividing machines.

LECTURE IV.—DECEMBER 16.—*Modern Ovens—Recently Invented Bread-making Processes.*—Old-type ovens.—Internally-heated ovens.—Requirements in an oven.—Furnace outside the bakery.—Should be economical in fuel and preferably smokeless.—Should retain its heat and also the steam produced by evaporation from the bread during baking.—Continuous baking.—Effect of materials used in oven-building.—Preference of many bakers for old-type ovens.—Modern inventions.—Various types of modern ovens.—Recently invented bread-making processes.—

Utilisation of germ.—Its objectionable qualities forcibly described by Graham.—New process of germ treatment.—Bread from germ flour.—Excessive diastasic properties of flour in former times.—Alum and other bodies used to prevent this action.—Introduction of diastase during the process of bread-making.—Valuation of bread.—Problem of securing effective control over supply of bread and flour to soldiers' barracks, workhouses, and other public institutions.—Conclusion.

The Second Course will be on "The Electromagnet." By Prof. SILVANUS P. THOMPSON. Four Lectures.

January 20, 27; February 3, 10.

The Third Course will be on "Stereotyping." By THOMAS BOLAS, F.C.S. Three Lectures.

February 17, 24; March 3.

The Fourth Course will be "Some Considerations concerning Colour and Colouring." By Prof. A. H. CHURCH. Three Lectures.

March 17, 24, 31.

The Fifth and Concluding Course will be on "Sugar, Tea, Coffee, and Cocoa, their Origin, Preparation, and Uses." By RICHARD BANNISTER. Four Lectures.

April 28; May 5, 12 19.

JUVENILE LECTURES.

Two Juvenile Lectures on "The Story of a Flame," will be given by Professor VIVIAN B. LEWES, on Wednesday evenings, January 1 and 8, 1890, at Seven o'clock.

PROCEEDINGS OF THE SOCIETY.

CHARTER.—THE SOCIETY OF ARTS was founded in 1754, and incorporated by Royal Charter in 1847, for "The Encouragement of the Arts, Manufactures, and Commerce of the Country, by bestowing rewards for such productions, inventions, or improvements as tend to the employment of the poor, to the increase of trade, and to the riches and honour of the kingdom; and for meritorious works in the various departments of the Fine Arts; for Discoveries, Inventions, and Improvements in Agriculture, Chemistry, Mechanics, Manufactures, and other useful Arts; for the application of such natural and artificial products, whether of Home, Colonial, or Foreign growth and manufacture, as may appear likely to afford fresh objects of industry, and to increase the trade of the realm by extending the sphere of British commerce; and generally to assist in the advancement, development, and practical application of every department of science in connection with the Arts, Manufactures, and Commerce of this country."

THE SESSION.—The Session commences in November, and ends in June. The number of Meetings held during the Session amounts to between 70 and 80.

ORDINARY MEETINGS.—At the Wednesday Evening Meetings during the Session papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed.

INDIAN SECTION.—This Section was established in 1869, for the discussion of subjects connected with our Indian Empire. Six or more Meetings are held during the Session.

FOREIGN AND COLONIAL SECTION.—This Section was formed in 1874, under the title of the African Section, for the discussion of subjects connected with the Continent of Africa. It was enlarged in 1879, so as to include the consideration of subjects connected with our Colonies and Dependencies, and with Foreign Countries. Six or more Meetings are held during the Session.

APPLIED ART SECTION.—This Section was formed in 1886 for the discussion of subjects connected with the industrial applications of the Fine Arts. Six or more meetings are held during the Session.

CANTOR LECTURES.—These Lectures originated in 1863, with a bequest by the late Dr. Cantor. There are several Courses every Session, and each course consists generally of two or more Lectures.

ADDITIONAL LECTURES.—Special Courses of Lectures are occasionally given.

JUVENILE LECTURES.—A short Course of Lectures, suited for a Juvenile audience, is delivered to the Children of Members during the Christmas Holidays.

ADMISSION TO MEETINGS.—Members have the right of attending the above Meetings and Lectures. They require no tickets, but are admitted on signing their names. Every Member can admit *two* friends to the Ordinary and Sectional Meetings, and *one* friend to the Cantor and other Lectures. Books of tickets for the purpose are supplied to the Members, but admission can be obtained on the personal introduction of a Member. For the Juvenile Lectures special tickets are issued.

JOURNAL OF THE SOCIETY OF ARTS.—The *Journal*, which is sent free to Members, is published weekly, and contains full Reports of all the Society's Proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce.

EXAMINATIONS.—Examinations are held annually by the Society, through the agency of Local Committees, at various centres in the country. They are open to any person. The subjects include the principal divisions of a Commercial Education, Political and Domestic Economy, and Music. A Programme, containing detailed information about the Examinations, can be had on application to the Secretary.

LIBRARY AND READING-ROOM.—The Library and Reading-room are open to Members, who are also entitled to borrow books.

CONVERSAZIONI are held, to which the Members are invited, each Member receiving a card for himself and a Lady.

MEMBERSHIP.

The Society numbers at present between three and four thousand Members. The Annual Subscription is Two Guineas, payable in advance, and dates from the quarter-day preceding election; or a Life Subscription of Twenty Guineas may be paid.

Every Member whose subscription is not in arrear is entitled:—

To be present at the Evening Meetings of the Society, and to introduce two visitors at such meetings, subject to such special arrangements as the Council may deem necessary to be made from time to time.

To be present and vote at all General Meetings of the Society.

To be present at the Cantor and other Lectures, and to introduce one visitor.

To have personal free admissions to all Exhibitions held by the Society at its house in the Adelphi.

To be present at all the Society's *Conversazioni.*

To receive a copy of the Weekly *Journal* published by the Society.

To the use of the Library and Reading-room.

Candidates for Membership are proposed by three Members, one of whom, at least, must sign on personal knowledge; or are nominated by the Council.

All subscriptions should be paid to the Secretary, H. T. Wood, and all Cheques or Post-office Orders should be crossed "Coutts and Company," and forwarded to him at the Society's House, John-street, Adelphi, London, W.C.

H. TRUEMAN WOOD, *Secretary.*

CALENDAR FOR THE SESSION.

The following is the Calendar for the Session 1889-90. It is issued subject to any necessary alterations:—

NOVEMBER, 1889.		
1	F	
2	S	
3	**S**	
4	M	
5	Tu	
6	W	
7	Th	
8	F	
9	S	
10	**S**	
11	M	
12	Tu	
13	W	
14	Th	
15	F	
16	S	
17	**S**	
18	M	
19	Tu	
20	W	Ordinary Meeting (Opening Meeting of the Session)
21	Th	
22	F	
23	S	
24	**S**	
25	M	Cantor Lecture I. 1
26	Tu	
27	W	Ordinary Meeting
28	Th	
29	F	
30	S	

DECEMBER, 1889.		
1	**S**	
2	M	Cantor Lecture I. 2
3	Tu	
4	W	Ordinary Meeting
5	Th	
6	F	
7	S	
8	**S**	
9	M	Cantor Lecture I. 3
10	Tu	
11	W	Ordinary Meeting
12	Th	
13	F	
14	S	
15	**S**	
16	M	Cantor Lecture I. 4
17	Tu	
18	W	Ordinary Meeting
19	Th	
20	F	
21	S	
22	**S**	
23	M	
24	Tu	
25	W	CHRISTMAS DAY
26	Th	*Bank Holiday*
27	F	
28	S	
29	**S**	
30	M	
31	Tu	

JANUARY, 1890.		
1	W	Juvenile Lecture 1
2	Th	
3	F	
4	S	
5	**S**	
6	M	
7	Tu	
8	W	Juvenile Lecture 2
9	Th	
10	F	
11	S	
12	**S**	
13	M	
14	Tu	
15	W	Ordinary Meeting
16	Th	
17	F	Indian Section
18	S	
19	**S**	
20	M	Cantor Lecture II. 1
21	Tu	For. & Col. Section
22	W	Ordinary Meeting
23	Th	
24	F	
25	S	
26	**S**	
27	M	Cantor Lecture II. 2
28	Tu	Applied Art Section
29	W	Ordinary Meeting
30	Th	
31	F	

FEBRUARY, 1890.		
1	S	
2	**S**	
3	M	Cantor Lecture II. 3
4	Tu	
5	W	Ordinary Meeting
6	Th	
7	F	Indian Section
8	S	
9	**S**	
10	M	Cantor Lecture II. 4
11	Tu	Applied Art Section
12	W	Ordinary Meeting
13	Th	
14	F	
15	S	
16	**S**	
17	M	Cantor Lecture III. 1
18	Tu	For. & Col. Section
19	W	Ordinary Meeting
20	Th	
21	F	
22	S	
23	**S**	
24	M	Cantor Lecture III. 2
25	Tu	
26	W	Ordinary Meeting
27	Th	
28	F	Indian Section

MARCH, 1890.		
1	S	
2	**S**	
3	M	Cantor Lecture III. 3
4	Tu	Applied Art Section
5	W	Ordinary Meeting
6	Th	
7	F	
8	S	
9	**S**	
10	M	
11	Tu	
12	W	Ordinary Meeting
13	Th	
14	F	Indian Section
15	S	
16	**S**	
17	M	Cantor Lecture IV. 1
18	Tu	For. & Col. Section
19	W	Ordinary Meeting
20	Th	
21	F	
22	S	
23	**S**	
24	M	Cantor Lecture IV. 2
25	Tu	Applied Art Section
26	W	Ordinary Meeting
27	Th	
28	F	
29	S	
30	**S**	
31	M	Cantor Lecture IV. 3

APRIL, 1890.		
1	Tu	
2	W	
3	Th	
4	F	GOOD FRIDAY
5	S	
6	**S**	EASTER SUNDAY
7	M	*Bank Holiday*
8	Tu	
9	W	
10	Th	
11	F	
12	S	
13	**S**	
14	M	
15	Tu	Applied Art Section
16	W	Ordinary Meeting
17	Th	
18	F	Indian Section
19	S	
20	**S**	
21	M	
22	Tu	For. & Col. Section
23	W	Ordinary Meeting
24	Th	
25	F	
26	S	
27	**S**	
28	M	Cantor Lecture V. 1
29	Tu	
30	W	Ordinary Meeting

MAY, 1890.		
1	Th	
2	F	
3	S	
4	**S**	
5	M	Cantor Lecture V. 2
6	Tu	For. & Col. Section
7	W	Ordinary Meeting
8	Th	
9	F	
10	S	
11	**S**	
12	M	Cantor Lecture V. 3
13	Tu	Applied Art Section
14	W	Ordinary Meeting
15	Th	
16	F	Indian Section
17	S	
18	**S**	
19	M	Cantor Lecture V. 4
20	Tu	For. & Col. Section
21	W	Ordinary Meeting
22	Th	
23	F	
24	S	
25	**S**	WHIT SUNDAY
26	M	*Bank Holiday*
27	Tu	
28	W	Ordinary Meeting
29	Th	
30	F	
31	S	

JUNE, 1890.		
1	**S**	
2	M	
3	Tu	
4	W	
5	Th	
6	F	
7	S	
8	**S**	
9	M	
10	Tu	
11	W	
12	Th	
13	F	
14	S	
15	**S**	
16	M	
17	Tu	
18	W	Annual Conversazione (probable date)
19	Th	
20	F	
21	S	
22	**S**	
23	M	
24	Tu	
25	W	Annual General Meeting
26	Th	
27	F	
28	S	
29	**S**	
30	M	

The chair will be taken at eight o'clock at each of the Ordinary Meetings, the Cantor Lectures, and the Meetings of the Applied Art Section.

The Meetings of the Indian and the Foreign and Colonial Sections will commence at five o'clock.

The Annual General Meeting will be held at four o'clock.

The Juvenile Lectures will be given at seven o'clock.

Proceedings of the Society.

FIRST ORDINARY MEETING.

Wednesday evening, November 20, 1889; SIR FREDERICK BRAMWELL, Bart., D.C.L., F.R.S., Deputy-Chairman of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Baldry, William Frank, 27, St. Oswald's-road, West Brompton, S.W.
Barlow, Crawford P., 2, Old Palace-yard, S.W., and Deene, Tooting Bec-road, Streatham, S.W.
Bishop, Henry, 41, Coleman-street, E.C.
Blease, Robert Stanley, Ashburn-lodge, Fairfield, Liverpool.
Bolton, Herbert, 28, Regent-street, Bacup, Lancashire.
Bourke, Walter Longley, Westbrook, Eccles, Manchester.
Bugby, William, Gas Works, Southall, Middlesex.
Burford, Samuel Francis, Eastleigh, Queen's-road, Leicester.
Carpenter, George, 12, DeCrespigny-park, Denmark-hill, S.E.
Carpmael, Ernest, 3, Harcourt-buildings, Temple, E.C.
Chapman, Samuel, 5, Elm-villas, Loughton, Essex.
Coddington, John George Thornton, Ballinasloe, Ireland.
Collis, Thomas James, 116, Cannon-street, E.C.
Congreve, Hubert, 4, Witney-terrace, Bowden, Cheshire.
Cooper, William, The Strand, Derby.
Cripps, Frederick Southwell, Clyde-house, Benhill-street, Sutton, Surrey.
Cuvilje, Oswald Bruce, 68, Upper Berkeley-street, Portman-square, W.
Dauber, Henry, junr., 7, Devonshire-place, Portland-place, W.
Davies, David Evan, Rhianfa, Pwllheli, North Wales.
Davies, Thomas, 1, Lombard-court, E.C.
Donaldson, Hay Frederick, Poplars, Bebington, Cheshire.
Dredge, James, 35, Bedford-street, Strand, W.C.
Easton, John Marshall, Redholm, Helensburgh, N.B.
Elgar, Prof. Francis, LL.D., The Admiralty, Whitehall, S.W., and 101, Inverness-terrace, W.
Fairholme, Captain Charles, R.N., 18, St. Dunstan's-hill, E.C.
Findlay, George, Euston Station, N.W.
Forbes, John, M.R.C.P., F.R.C.S., 8, Johnstone-street, Bath.
Golby, Frederick William, 54, Fleet-street, E.C.
Gray, Alexander, 25, Greenhill-road, Hampstead, N.W.
Hart, Thomas, Yewbarrow, Grange-over-Sands, Lancashire.
Henderson, George William, 17, Chesham-place, S.W.
Hobbes, Robert George, Livingstone-house, 374, Wandsworth-road, S.W.
Hoey, David George, Commercial Bank-buildings, 8, Gordon-street, Glasgow.
Holt, Robert Burbank, 10, Bedford-place, Russell-square, W.C.
Hooley, Cosmo Charles, The Union Offices, Patricroft, Manchester.
Hutton, Herbert Ansted, Merlewood, Chislehurst, Kent.
Innes, Lieut.-General James John McLeod, V.C., 9, Lexham-gardens, Kensington, W.
Innes, James William, 4, Tokenhouse-buildings, E.C., and Cheltenham-square, Harrogate.
Jackson, John, 17, Victoria-street, Westminster, S.W.
Jardine, Mrs., 51, Lancaster-gate, W.
Jewell, George Beer, Easton-terrace, Yeovil.
Jones, Arthur Daniel, Engineer's-office, Surrey Commercial Docks, Rotherhithe, S.E.
Kapteyn, Albert, Canal-road, King's-cross, N.
Lancaster, John, Anfield-house, Leamington.
Lindsay, Thomas Steven, 4, Oak-hill-park, Frognal, Hampstead, N.W.
Livsey, John Edward, 34, Octavia-street, Battersea, S.W.
McIntyre, Matthew, R.N., 68, Crofton-road, Camberwell, S.E.
Manson, Frederick William, 36, New Broad-street, E.C.
Marshall, Percy Edward, 25, College-hill, E.C.
Matthews, Charles P., J.P., The Bower-house, Havering, Essex.
May, William Holmes, 14, Queen Victoria-street, E.C., and Nutfield-house, Balham, S.W.
Mège, Roch Raymond, 9, Spring-gardens, S.W.
Miller, Thomas Robson, Westminster Palace Hotel, S.W.
Mortimer, John Robert, Driffield, Yorkshire.
Mosley, Colonel Paget, 27, St. James's-square, S.W., and Carlton Club, S.W.
Moxon, Charles Frederick, Beach-cliff, Westgate-on-Sea.
Mudd, Thomas, Hartlepool.
Myring, Jacob, 13, Marlborough-road, St. John's-wood, N.W.
Nunn, Francis Crumpton, Eastnor, Sydenham-hill, S.E.
Orrock, James, 48, Bedford-square, W.C.
Papworth, Wyatt, 33, Bloomsbury-street, W.C.
Payne, John Bruce, M.A., Cloford-house, Kirkley-cliff, Lowestoft.
Petre, Lord, 21, Hyde-park-gardens, W., and Thorndon-hall, Essex.
Platt, James, Somerset-villa, Gloucester.
Praed, Fitzpatrick, 73, Eccleston-square, S.W.
Provis, Thomas Bawden, 76, Finsbury-pavement, E.C.

Quick, Frederic William, 510, Mansion-house-chambers, E.C.
Rait, George Thomas, 70, Bishopsgate-street within, E.C.
Rooper, Henry Napier, 17, Lincoln's-inn-fields, W.C.
Rust, Arthur, Eversleigh, Leicester.
Smith, John, 8, Old Jewry, E.C., and 346, Camden-road, N.
Smith, Sidney Robert James, 15, York-buildings, Adelphi. W.C.
Smithe, William Arthur, B.A., 53, Wool Exchange, Coleman-street, E.C., and 39, Elm-grove, Cricklewood, N.W.
Spain, Harry George Guthrie, St. Thomas, West Indies.
Steel, John, Cheribon, Preston-park, Brighton.
Stiff, William Charles, Credenda Seamless Steel Tube Works, Ledsam-street, Birmingham.
Stocker, Alonzo Henry, M.D., Peckham-house, Peckham, S.E.
Straker, Sidney, 240, Stanstead-road, Forest-hill, S.E.
Sykes, George Henry, M.A., 12, Albert-square, Clapham, S.W
Taylor, Jonas Dearnley, Springfield, Halifax.
Thomson, Charles Skeldon, B.Sc., Ormskirk, Durham-road, Cottenham-park, Wimbledon.
Thomson, John Millar, King's College, W.C.
Towler, Alfred, 31, Bismarck-street, Beeston-hill, Leeds.
Vaughan, James, 40, Gloucester-terrace, Hyde-park, W.
Weyman, James Edwardes, Church Acre Iron Works, Guildford.
White, Henry Watkins, 122, Lavender-hill, S.W.
Wilshire, Ruthven Matcham, 57, Stephanien-strasse, Carlsruhe, Germany.
Woodall, John Woodall, M.A., J.P., St. Nicholas-house, Scarborough, Yorks.

SIR FREDERICK BRAMWELL then read

THE CHAIRMAN'S ADDRESS.

When the Society of Arts was founded, in 1754, it was indeed a time of great intellectual activity, but this activity was manifested in the direction of literature rather than that of science, or even of art. It was near the close of a great literary epoch; it was before the commencement of the great scientific movement in the midst of which we now are. Johnson was in his prime; his dictionary was published in 1755, a year after the foundation of the Society. Pope was dead ten years before, but Goldsmith, Sterne, Richardson, Fielding, Smollett, Gray, Hume, and Burke were all living and writing about this time.

In the domain of art, it is true, if, when the Society was founded, the fine arts cannot be said to have been in a flourishing condition in England, at least they were not at their lowest. The men, however, were alive who were destined to raise the character of this country in this particular. Hogarth was vigorously urging the claims of art to exert a real influence upon the life of the nation, and Boydell was just commencing those labours which in the end were so thoroughly successful in forming an English school of engraving. Reynolds had lately settled in London, but Gainsborough and Romney had not yet done so.

Architecture, too, after a relapse since the great days of Wren, was on the eve of, at all events, some slight improvement. Stuart and Revett had lately returned from Greece, and the publication in 1748 of their work on the architecture of Athens had exerted considerable influence in the revival of Greek art. One of the prominent results of this publication is exhibited in the work of the brothers Adam, which is to be seen in this house and in the district where we meet—the Adelphi.

But little progress had been made in the development of science and its applications; Lavoisier, the father of modern chemistry, was not born till 1743. Without any means of accurate measurement—for the balance, as a instrument of chemical research was unknown—chemical investigation as we understand it now was impossible, and even the elementary facts on the results of which modern industrial chemistry is founded, were undiscovered. Priestley was a young man of 21, and had not yet turned his attention to the discoveries which afterwards made his name famous. Philosophers were beginning to experiment with electricity. Franklin sent up his electrical kite just about this time. A few years previously Cunæus had half killed himself with a Leyden jar; and Canton had received a Royal Society's medal for his "method of making artificial magnets."

The telegraph indeed, not to be completed until nearly a century later, had been suggested, and many curious experiments had been made illustrating, though the experimenters were unaware of it, one of the greatest of the powers of electricity, that of conveying energy to a distance.

Ships were still navigated across the Atlantic by dead-reckoning, for Harrison had not yet received the award for the chronometer, by which alone it was possible to calculate the longitude. Dollond had just constructed, if not the first achromatic telescope, at least the first which was brought into practical use.

In industry and mechanical invention we were almost more backward. Not yet had Watt's attention been directed to the steam-engine. The engines, excellent as they were, of Newcomen were employed only for pumping water, principally from mines. Where a steam-engine was used to supply motive power it was only by the roundabout proceeding of setting an engine to pump up water, which drove a water-wheel for the purpose of working forge bellows. Such motive power as was available, apart from that supplied by men and animals, was the power of wind and of water. Windmills were of course used for such purposes as grinding corn, and draining land by pumping, while water mills were used to a large extent for driving forge hammers.

Even in those cases where inventive skill was present, the power to carry out invention was lacking, for the tools available were but of a simple and imperfect character, and many of the faults of the earlier steam-engines were due, not to any defect in the method of their design, but to the impossibility of getting cylinders truly cylindrical, or the working parts of the engine to fit together.

Charcoal was still the one fuel for iron manufacture. The inventions of Dudley and others for smelting iron with coal had been forgotten, or could not be carried into effect until, at Coalbrookdale, Darby succeeded in solving the problem, and set up works for the manufacture of iron on a large scale with coal.

So dependent upon charcoal for fuel was this industry, that Sussex was still one of the principal seats of the iron manufacture in England. The destruction of its woods had led to many complaints and to some legislation on the subject, and the manufacture was consequently dying out; but still ten out of the fifty-nine furnaces in England in 1740 were situated in Sussex.

All textile fabrics were of course made on hand-looms, while the yarn from which they were made was spun much in the same fashion as it had been a thousand years before. Paul and Wyatt had indeed constructed a machine for spinning by rollers; but this, like many other inventions of those days, was forgotten; until Hargreaves in 1767 invented the spinning-jenny; and in 1769 Arkwright took out the patents embodying spinning by rollers, on which his great fortune was founded.

It was, however, a time when industrial activity was commencing, and no doubt it was the spirit which then existed which led a small knot of men, sensible of the need which the arts and manufactures of the country had of encouragement, to found a Society with that aim and end. The first way in which they set about the work was by offering prizes for such objects as they thought to be required, with a view to drawing attention to the necessity, and encouraging men to come forward to supply the want. In many cases these early pioneers of industrial science showed considerable foresight; in others they were of course mistaken. Some of their proposals were futile, others were incapable of realisation; but in others, again, we are struck by the insight shown, for many of these old suggestions have been brought to effect under the altered circumstances of our own time.

As the country had been to a large extent depleted of timber, by the necessity of building ships, and also by the wants of the iron manufactures, the Society offered numerous prizes to those landed proprietors and others who would plant a certain number of trees. and it is to this action on the part of the Society that many of our fine existing woods are due. In agriculture also, the necessity for mechanical methods of doing what had up to that time only been accomplished by hand implements, impressed itself upon the Society, and prizes were offered for all sorts of agricultural implements—reapers, mowers, ploughs, drills, &c.

A needless dread of monopoly, and a mistaken view as to the result of patenting inventions, led the Society to refuse any award to a patented article, and thus excluded from its prize-lists many of the most important inventions of the time. But for this unfortunate regulation, there is no doubt that the Society of Arts would at the latter part of the last century have had much greater and more useful effect upon the progress of mechanical science in this country than it actually had. As it was, there can be no doubt of the effect of the offer of the Society's prizes on the mechanical science of the times, on its textile industries, its chemistry, its agriculture, and on its trade, especially the trade with "His Majesty's Colonies and Plantations abroad."

It is certain that the system of award of prizes for specified objects worked much good in its time, and that the very large sums spent by the Society in those early days produced their practical results; but the growth of science, and its constantly increasing application to industry, rendered the system obsolete. The rewards obtained by successful inventors made the attraction of prizes, in comparison, very slight; while the needs of the public offered a better guide to the direction which inventors could most profitably follow than the theoretical notions of a committee, however capable and hard working. Thus the system of offering prizes for meritorious inventions and improvements, once the main object of the Society's efforts, dropped into the second place. Not, indeed, that it was ever wholly abandoned, for a list of the objects for which awards were offered was continued down to 1873, and even at the present time it is found occasionally useful to try and direct public attention to some specified object by the means of an offered prize.

In the early part of the century there was a great need that the public generally should be enlightened as to the progress both of science and of industry. One of the first to perceive this was probably Count Rumford, the founder of the Royal Institution. He may be considered to have been the first popular educator in science, and the courses of lectures which from the days of Davy down to the present time have been delivered in Count Rumford's theatre have, it is unnecessary to say, been of the greatest educational value.

In the Society, work of a similar character was being carried on, and by one whose services to popular education may fairly be named with those of Davy and of Faraday. Arthur Aikin was secretary of the Society from 1816 to 1839, and during this period he had inaugurated series of popular lectures, each of which dealt with some art or manufacture. For year after year he devoted himself to this work, and the lectures which he delivered are still a faithful guide to the condition of very many industries at that time. Aikin's idea has developed until it has practically become the principal work of the Society of Arts—the dissemination of information about the relations of science and art to industry is the object of the papers and discussions at the evening meetings, and is the very basis of the invaluable courses of Cantor lectures which have now been delivered since the year 1863.

It was Aikin also who first endeavoured to form collections illustrative of industrial progress. These collections grew into the Society's Repository of Inventions, which for a long time offered inventors a most valuable means of bringing their apparatus before the notice of the public. They also developed in another direction into special exhibitions, collected for a short time and afterwards removed; whereas the museum or repository was of a permanent nature. These special exhibitions, which were held in the Society's premises from 1846, led to the idea of a larger national exhibition of the products of British industry.

A proposal being submitted to the Prince Consort, then the President of the Society, he at once decided that it might take even a larger scope, and the Great Exhibition of 1851 was therefore international. This development, and carrying into successful execution of the idea of exhibtions such as we know them, is certainly the most important work that the Society in its corporate capacity has ever effected. To the efforts of those who then guided its destinies was due the Exhibition of 1851, and in an equal degree that of 1862.

The Society has been connected in one capacity or another with many of the great foreign exhibitions, and wherever any difficulty in exhibition organisation has been felt, wherever the need for a permanent institution has been found which should connect the intermittent efforts of temporary organisation, each of necessity perishing when its work was over, the Society of Arts has always been ready and willing to assist in satisfying this need.

It rendered important service to the organisation of that most successful series of Exhibitions held at South Kensington from 1883 to 1886, and, as you are aware, it has had a close though indirect connection with the great Exhibition just closed in Paris. It is admitted on all sides that it was a matter for great regret that political considerations should have prevented this country, in common with the other monarchies of Europe, from taking an official part in the French Exhibition of 1889; nor did it seem desirable that the Society should be officially associated with an exhibition in a foreign country with which the Government of our own country had definitely refused to have any connection. The Council were, however, anxious to promote the interests of British exhibitors, and they readily consented to the Secretary of the Society taking charge—under the Committee which had been organised for the purpose at the Mansion-house through the instrumentality of the then Lord Mayor, Sir Polydore De Keyser—of the British Section. They have every reason to be gratified at the result of their action.

The success which has been achieved by the Section is acknowledged on all sides, and it certainly formed no unworthy part of the greatest and most remarkable Exhibition which the world has yet seen. That this has been done, as I am informed it has been done, without any cost to the country, at the expense of the exhibitors alone, and with no assistance except some £1,500 worth of subscriptions for the Fine Art Section, is a matter for distinct congratulation on the part of all concerned, and is an entirely new departure in the management of Sections of Foreign Exhibitions, which have previously cost the country sums varying from £120,000 to £40,000 each. I must, therefore, be permitted to take some credit to the Society of Arts for having supplied the Executive Committee of the Exhibition with an administration capable of bringing about such a result.

The great spread of exhibitions, their popularity in this country and abroad, certainly seems to indicate the necessity for some permanent organisation which, at all events so far as regards foreign exhibitions, might properly deal with this important subject, and ensure that British interests abroad were not neglected. Foreign exhibitions form a valuable means of advertising, and a not very costly one. They bring British wares prominently under the notice of the people of the country in which they are held, and in the present condition of trade we cannot afford to neglect any opportunity of the sort; but individual manufacturers and traders cannot act without some central organisation. It is even a question whether they can act very efficiently without pecuniary aid from the Government. In the case of the great Exhibition in Paris, it has been shown that this could be done; but it is doubtful whether the same rule could be applied in the case of smaller exhibitions on the Continent.

It must be remembered that it is not always the individual trader, the exhibitor, who reaps the profit, so much as it is the particular industry illustrated by his individual exhibit. While, therefore, it is the interest of the country that England should take part in all foreign exhibitions of an important character, it does not necessarily follow that it is worth while for individuals to go to the considerable expense involved. It would therefore seem very desirable that some small funds should be forthcoming from Government, and if this were so, I am sure the Society of Arts would always be ready to provide the necessary organisation, and to direct the expenditure.

The work of the Society to which I have been referring is in the widest sense educational, but I should like also to refer to the share which the Society has taken in the diffusion of education in its strictest sense. It was in this building that the great examination system originated which is now certainly the potent instrument in this country for the advancement of scientific instruction, since it was the Society which originated the system of local examinations directed from a single centre, which has since developed into the Science and Art Department. But besides branching out into extensions too great for the moderate funds of the Society to deal with, the system of examinations, which was started with a test examination in Huddersfield in 1857, has done, and is still doing, very valuable work under the control of the Society itself. It has received many and extensive modifications, but is still progressing. The Society also made the experiment of technological examinations, and as soon as the experiment showed promise of success, the Society succeeded in handing their examinations over to the important organisation of the City Companies, which has rendered such great services to technical education. Under its judicious care, and with the ample funds contributed by the companies, the system of technological examinations has grown to an extent it could never have reached under the charge of the Society of Arts, whose moderate means are required for too many purposes to make it possible to devote any considerable sum to a single special object.

We are now making a similar experiment with regard to examinations in commercial knowledge. Should it succeed we shall doubtless find somebody able and willing to continue it, and on a larger scale than our own resources permit, while if in its present form it should be unsuccessful, we shall endeavour to modify it; or if it should prove that the public do not want examinations of such a character we shall abandon the proposal altogether, and shall direct our energies to some other field of education. This is, and should always continue to be, an important province of our Society; to nurse fresh institutions into existence, work them for a time, and if they succeed and gain strength for independent existence, to start them forth into the world; while if they show no signs of permanent vitality, to let them perish, as soon as their uselessness is certainly ascertained.

A most important and interesting branch of the Society of Arts' work has long been the application of art to industry, and, indeed, this was one of the special objects to which the Prince Consort, on his assumption of the Presidentship, directed the Society's attention. Not, indeed, that the Society had ever neglected the fine arts. In fact, shortly after its foundation the Society granted the use of its room for the exhibition of the works of native artists, and out of these exhibitions grew the Royal Academy. The Society further attempted to encourage pictorial art by the offer of prizes, some of which were obtained by youths who afterwards became distinguished artists. Cosway and Smart were the first of these but the list was continued by Nollekens and Flaxman among sculptors, and by Turner, Landseer, and Mulready among painters, till it reached our own days with the name of our great living artist, Sir John Millais. But the growth of the Royal Academy left the Society little to do in the advancement of the fine arts, though several important exhibitions, notably those of the works of Etty and Mulready, were held in the Adelphi.

More congenial work was found in the effort to elevate our art industries, or, rather, to re-establish them, for in the first half of the present century they can hardly be said to have existed. The first attempt was one which at the time met with a certain amount of friendly ridicule. Prizes were offered for the production of articles of everyday use, but of artistic form. Several of these prizes were taken by Messrs. Minton for articles designed by Mr. Cole, and sent in under an assumed name. This was the starting point of our modern art industries.

Under the vigorous impulse imparted to it by Mr. Cole the work was carried on by the schools of design, out of which grew the great Art Department of South Kensington. Here, again, the Society started a movement which rapidly outgrew its own resources, and its own power of developit. But it did not, all the same, neglect that movement. In many ways the Society has fostered the popular love for beautiful and artistic objects, a fostering which has educated and directed the feeling it had aroused. This it has done by constant lectures, by numerous small exhibitions, by prizes, and notably by the long series of prizes to art-workmen, now, after a lapse of some years, renewed under modified conditions by the foundation of such institutions as the National School of Wood-carving, &c.

At present it devotes the labours of one of its Sections—the Section of Applied Art—specially to this subject, at the head of that Section is a thoroughly representative committee. Its most recent action has been the renewal of the prizes offered to art-workmen, in the hope of encouraging craftsmen themselves to produce original works of art, but it will always be ready to take up any line of action which may serve to promote the development of art and its continued application to industrial purposes.

The question of food supply has been dealt with by the Society of Arts almost since its foundation, but it is only of recent times that it has taken up sanitary questions. Domestic sanitation owes a great deal to the Society; indeed, it would not be too much to say that the position these questions have occupied in recent years in the public mind has been entirely due to the Society of Arts. When the first Sanitary Congress of the Society was held in 1876, though enormous progress had been made in municipal sanitation, the advance in house sanitation had been comparatively slow. The whole subject was thoroughly dealt with here, public attention was attracted, and the public were educated in the subject. The result is seen in the enormous improvements which have been made in houses constructed during the past ten years or so. It is not of course to be supposed that there does not yet remain very much to be done; but there is no doubt that London, and all our other great cities, are in a far healthier state than they were when the Society of Arts' Sanitary Conferences were commenced. The very agencies which have sprung into existence for investigating and reporting on the sanitary condition of houses also owe their origin to the Society, the suggestion for the establishment of the first of them having been made here in a paper by the late Professor Fleeming Jenkin. We have also dealt to a considerable extent with the kindred question of water supply, but here there is yet more to be done, and this is a question on which probably the Society of Arts has not said its last word.

The question of smoke abatement is one with which of late years we have had little to do, as special and independent agencies have been organised for the purpose. More than a hundred years ago, however—in 1784—the Society offered a prize for a method of "destroying smoke," a prize which, though the offer was repeated for many years, appears not to have been awarded. This is, perhaps, a question which in time to come the Society might again take up, with a view to ascertaining the best means for obtaining heat without the terrible blackening of the atmosphere which goes on over all our large cities. It would appear that this vitiated atmosphere extends but to a very small distance from the surface of the earth, and there seems no reason to despair of our devising some means by which its production can be in part prevented, and if any of it is inevitable, that that part may be removed or so diluted as to become innocuous. In this matter legislation must go hand-in-hand with scientific improvement, but until we can be certain of having obtained better methods of combustion, it would be not only idle but also mischievous to pass laws against using the imperfect methods which are now all on which we have to depend.

The question of the patent-law is one which touches the Society very closely. The Act of 1852 by which the first and greatest reform in patents was effected, was largely due to the work of a committee of the Society of Arts, while those who are interested in the matter are well aware that the latest Act, 1883, was to a great extent founded upon a Bill drafted by a committee of this Society, and brought in for two successive years by members of its Council in the House of Commons. It is to the Society that the law of fine art copyright in this country is due, as it was by the active exertions of one of its committees that the Fine Art Copyright Bill of 1862 was passed. The cheapening of telegrams, and the establishment of the parcel post are matters which the Society pressed upon successive Postmasters-General, until at last they were carried into effect.

There is one very useful function which the Society of Arts might discharge, though unfortunately it is one which requires the command of considerable resources. I mean the carrying out of researches into problems of an applied science nature, such as are not likely to be pursued without a little encouragement. Such, for instance, are the important investigations which the Institution of Mechanical Engineers has been carrying out into the properties of steel, the tests of steam-engines made by the Royal Agricultural Society, and the tests of gas-engines made by this Society a year ago. Such investigations as these, however, are very costly, even when it is possible to find eminent men of science ready to devote a considerable amount of time and labour to such work. You know that a large amount of valuable work is carried on in purely scientific matters by the British Association. All this is done by amateur committees, aided by small grants for expenses from the association's funds. This shows how many ready workers there are, provided the needful pecuniary assistance is forthcoming. Perhaps more might be done by the Society in the future in directions such as this, without interfering with the special organisations established since its foundation to deal with special branches of science.

So far, then, as it is possible to sum up the labours of a multifarious organisation such as our own, the work of the Society of Arts may be said to consist of the encouragement of all applications of science and art to purposes of daily life, and the diffusion of useful knowledge on the same subject. There are numerous independent associations—many of these sprung directly or indirectly from the Society—which occupy themselves with special branches of science and art, thereby rendering it difficult and indeed unnecessary for the Society to deal with such branches. Its power, however, lies in the universality of its scope of action.

There are two views of science; the view taken by the searcher after absolute knowledge, who is content to seek information for its own sake, who extends the boundaries of human knowledge even still further into the unknown, animated simply by the desire for its extension; the other that of those who will say that the test of the value of any scientific discovery is its power of immediate application, and the amount of money which can be realised by the sale of a patent for it.

With respect to the first class, these men indeed are among the noblest and greatest of our kind, but they are rare. Not every generation produces a Galileo, a Newton, a Darwin, or a Joule. These men make their fellows the wiser and the better for their wisdom. The task of making life happier and less hard is perhaps less noble, but fortunately it can be undertaken by minds of a less elevated but of a more frequent type. That is the task of the second class, of the great race of inventors who are really the masters of the nineteenth century, who have subdued the forces of nature to the service of mankind, and have applied the knowledge gained in the pursuit of pure science to the daily uses of industry. Very often in that application they have enormously increased the extent of knowledge itself, as has conspicuously happened in the case of electricity, a science which owes very much of its development to the practical applications that have been made of its discoveries.

It is with the works of this second class that it is the special province of the Society of Arts to deal, and now that so many keen intellects are intent on turning every scientific discovery to practical account, it is seldom that any fresh advance in science does not soon find its practical application, and thus come within the range of our Society's work. As, a generation ago, researches—at the time merely curious—into the effects of light on certain salts produced photography; as speculations on the behaviour of the magnetic needle rendered telegraphy possible; so in our own days investigations into the minutest forms of life have saved from destruction one industry—the silk manufacture—and revolutionised another—brewing; while they have absolutely changed our ideas about the conditions of healthy existence, and by exposing the origin of a large proportion of our diseases, have taught us how to avoid them, or, at least, how to minimise their evil effects.

It is the special duty of the Society to watch the beginning of all such applications of science; to foster them when such fostering is wanted, and is possible; to promulgate a knowledge of them, so as to ensure that the greatest number may avail themselves of that knowledge; and to assist them in the great struggle that all fresh knowledge has to endure against the constant opposition of ignorance and sloth. This, I venture to think, is no ignoble, no insufficient task for any institution. So long as we can carry it out honestly and well we shall not feel that our labours are ill-bestowed, or fear to lose that public approbation which has supported us during the last hundred and forty years, and may, I hope, support our successors for a hundred and forty years to come.

SIR DOUGLAS GALTON, K.C.B., F.R.S., moved a hearty vote of thanks to his Grace the Duke of Abercorn for his address, and to Sir Frederick Bramwell for reading it. He said that all present must appreciate the very interesting summary of the work which the Society had done during the course of its long history. As this address showed, the Society had been instrumental in pushing forward most of the great improvements which had taken place during the last century in the social condition of the community; and the members might well congratulate themselves on the work the Society had thus been the means of accomplishing. Many improvements in the Post-office originated there, and were pushed forward by members of the Society, and the same might be said of many other great improvements. He was sure, therefore, that they would all join heartily in passing the vote of thanks.

LORD ALFRED S. CHURCHILL, in seconding the resolution, said that he had on no previous occasion listened to an opening address which entered so fully into the past history of the Society, which had been the parent of so many flourishing societies, and taken a leading part in diffusing the benefits of art and science throughout the country.

The resolution having been carried unanimously,

SIR FREDERICK BRAMWELL, in reply, said it would be a satisfaction to the Duke of Abercorn to know that the address he had prepared had met with the approbation of the meeting, and the resolution which had been so warmly received should be communicated to him. For his own part, he had only done his duty as Deputy-Chairman of the Council in taking the place of his principal, who was unavoidably absent. It must be very gratifying to all the members to be able to look back upon such a record of work during 140 years. Many matters which now seemed very plain and obvious were not so plain and obvious when they were initiated, and great credit was due to those who took these things up before they became popular, and insisted on their value until they had convinced others of their importance.

The CHAIRMAN then presented the following medals awarded for papers read during the last session:—

To W. H. DEERING, F.C.S., for his paper on "Explosives."

To W. J. DIBDIN, F.I.C., F.C.S., for his paper on "Standards of Light."

To CONRAD BECK, for his paper on "The Construction of Photographic Lenses."

To Prof. SILVANUS P. THOMPSON, for his paper on "Arc Lamps and their Mechanism."

To A. B. W. KENNEDY, F.R.S., for his paper on "The Objects and Methods of the Society of Arts' Motor Trials."

To GEORGE CLULOW, for his paper on the "Origin and Manufacture of Playing Cards."

To Capt. WIGGINS, F.R.G.S., for his paper on "The Northern Waterway to Siberia."

To Major-General Sir R. MURDOCH SMITH, K.C.M.G., for his paper on "The Karún as a Trade Route."

To JOHN MCDOUGALL, for his paper on "Indian Wheats."

To Sir JAMES D. LINTON, P.R.I., for his paper on "Some Recent Movements in Relation to the Applied Arts."

To H. H. STATHAM, for his paper on "Architecture in Relation to Landscape."

Miscellaneous.

SILK INDUSTRY OF CHINA.

From a memorandum appended to the last report of the United States Consul at Shanghai, it appears that the greatest silk-producing province in China is Che-Kiang, and Kiang-Su comes second. The two great divisions in silk as exported from central China are known in all places of consumption as *tsatlees* and *taysaams*. Tsatlee is simply the Cantonese for *tseih le*, or seven li, that is to say an area of that dimension, taking Nanzing as the centre, where the best fine-sized silk was formerly produced. The radius has been extended, in consequence of the higher price paid for fine, compared with coarse sorts, and tsatlees now include some silks reeled from Sinsze and Seloo cocoons, which formerly were only employed for silks of the coarser thread; considerable quantities of taysaams are still, however, being reeled in the two last-named districts. At the present time tsatlee means silk produced at Nanzing, Chinza, Linglooh, Shwangling, Woochin, Leensze, Hoochow, and a portion of Sinsze and Seloo, besides the intermediate towns, all situated in Che-Kiang. Taysaam, meaning "a big worm," has really only the signification of silks of a coarse reeling, and under the denomination are classed silks from Kiahsing, Sinsze, Dongse, Shaouhing, Woosieh, and Laeyang, the last two districts being situated in Kiang-Su. Haining or Yuenfa, situate in Che-Kiang, produces silk reeled of the finest size known in China, and when native competition was crippled by the Tai-Ping rebellion large quantities annually found a ready sale in Europe. Of late years, however, the export has dwindled down to almost nothing. Hang-Chow, also in Che-Kiang, produces both fine and coarse sized silks, tsatlees and taysaams, the size of the former from this district very nearly approaching to that of Kiahsing taysaams, and they are generally in favour both for export and for home use, whilst the coarse sorts are mostly taken by Chinese. Shaouhing, in Che-Kiang, produces a very considerable quantity of silk that when reeled on foreign methods is said to be equal to any in the empire, but which, as natives persist in reeling on a large wheel and without care, has gradually lost all interest to foreigners. Laehang, in Kiang-Su, produces from 3,000 to 4,000 bales annually, but the same remarks as those applied to the Shaouhing production must apply also to this district's production. The principal towns where throwing is carried on are Nanking, Soo-Chow, and Hang-Chow, and the business must be large to meet the requirements of the enormous piece goods trade of China. Formerly foreigners used to export considerable quantities; but the improvements made in Europe which have not extended to China have extinguished the trade. The re-reeling of silks (for the purpose of rendering the manipulation of the silk easier to manufacture) is carried on in the centres of Nanzing and Chinza, and the outlying farms and hamlets. The production is considerable, and would be larger, it is said, if the Chinese would use greater care and abstain from adulterating the silk during the process.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, Nov. 25...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. William Jago, "Modern Developments of Bread-making." (Lecture I.)

East India Association, Westminster Town-hall, S.W., 2½ p.m. Sir Richard Temple, "India in the House of Commons."

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Mr. J. Theodore Bent, "The Bahrein Islands, Persian Gulf."

Actuaries, The Quadrangle, King's College, W.C., 7 p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Sir R. S. Ball, "Shooting Stars."

TUESDAY, Nov. 26...Medical and Chirurgical, 20, Hanover-square, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on Mr. John I. Thornycroft's paper, "Water-Tube Steam-Boilers for Marine Engines."

Anthropological, 3, Hanover-square, W., 8½ p.m Prof. A. C. Haddon, "The Ethnology of the Western Tribe of Torres Straits."

WEDNESDAY, Nov. 27...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Dr. J. Hall Gladstone, "Scientific and Technical Instruction in Elementary Schools."

Microscopical, King's College, W.C., 8 p.m. Conversazione.

Inventors' Institute, 27, Chancery-lane, W.C., 8 p.m. Discussion on Resolutions passed at the recent International Congress on Industrial Property.

Royal Society of Literature, 21, Delahay-street, S.W., 1 p m.

THURSDAY, Nov. 28...Antiquaries, Burlington-house, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 6 p.m. Prof. Ray Lankester, "Mithridates and the Scorpion."

Electrical Engineers, 25, Great George-street, S.W., 8 p.m. Mr. G. L. Addenbroke, "Electrical Engineering in America."

FRIDAY, Nov. 29...Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. G. H. Sheffield, "Principles of Iron Foundry Practice."

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FRIDAY, NOVEMBER 29 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

Mr. William Jago delivered the first lecture of his course on "Modern Developments of Bread-making," on Monday evening, 25th inst., when he dealt chiefly with the subject of the selection of flours.

The lectures will be printed in the *Journal* during the Christmas recess.

Proceedings of the Society.

SECOND ORDINARY MEETING.

Wednesday, November 27, 1889; the Right Honourable A. J. Mundella, M.P., in the chair.

The following candidates were proposed for election as members of the Society:—

Black, Surgeon-Major William G., F.R.C.S.E., M.R.C.S., 2, George-square, Edinburgh.
Brooke, Walter, St. Helier, Dynevor-road, Richmond, Surrey.
Compton-Smith, William Compton, 22, Sumner-place, South Kensington, S.W.
Ellis, Basil Pym, 9, Southwick-crescent, Hyde-park, W.
Flint, Charles A., 12, St. Helen's-place, E.C.
Harrison, William J., 7, Carteret-street, Westminster, S.W.
Lorenzen, Christian Carl, 149, Minories, E.
Smyth, William Stopford, Newport, Monmouthshire
Sutton, Joseph W., Sunnyside-cottage, Thames Ditton.
Thomas, Joseph, Engineer's Office, Royal Victoria Docks, E.
Thompson, Thomas William, Eastham Ferry, near Birkenhead.

The paper read was—

SCIENTIFIC AND TECHNICAL INSTRUCTION IN ELEMENTARY SCHOOLS.

By J. H. Gladstone, Ph.D., F.R.S

On preparing for this evening, I naturally looked up a paper which I had the honour of reading before our Society in December, 1878 (Society of Arts *Journal*, vol. xxvii., p. 63). It was on "Science Teaching in Elementary Schools." I was struck by a close analogy between the state of things then, and that which now obtains in regard to technical instruction. Then, as now, the aid of the Government was invoked, and the first attempts to comply with the demands of educationists were inadequate and sometimes inoperative. The history of the intervening years is instructive, therefore, as bearing upon the educational controversies of the present day.

Scientific Instruction.

The science with which we have to deal is, of course, restricted to that of nature, and to that knowledge of natural objects and phenomena which is within the comprehension of a child. Eleven years ago such instruction, in the form of object lessons and elementary notions of animal physiology, or other scientific subjects, was approved by educational reformers, was supported by the example of Continental nations, and was attempted by the London School Board and other large educational institutions. It was claimed, in the paper already alluded to, that this teaching should be demonstrative and experimental, and should have a bearing on the practical life and future occupations of the scholars. The Government code gave no encouragement, except that certain sciences might be taught as "specific subjects of secular instruction," and earn a grant. On the other hand, the code insisted on high attainments in reading, writing, which includes the mysteries of spelling, and abstract arithmetic. There was no provision that the child's natural curiosity and activity should be gratified, so that these qualities ran great danger of being atrophied through disuse; there was little, too, in the curriculum to evoke any of the perceptive powers or the intelligence of the child.

In the new code of 1880 the words "object lessons" appeared in a note, and referred both to the infant school and upper departments, and it was arranged that a grant should be given if the class passed a creditable examination in certain definite subjects of instruction taught through reading lessons, illustrated if necessary by maps, diagrams, specimens, &c. These subjects include such scientific teaching as that of geography, natural history, physical geography, or natural philosophy; but evidently it was contemplated that the knowledge of nature was to be given by the written descriptions rather than by the things themselves.

In the following year, 1881, Mr. Mundella, the Vice-president of the Committee of Council on Education, laid upon the table of the House of Commons certain proposals for the revision of the code; among these it was suggested that in infant schools the full grant would not be paid unless there was provided "a systematic course of simple lessons on objects, and on the phenomena of nature and of common life," and that the benefit of elementary science teaching might be given to the elder children otherwise than "through reading lessons." As these proposals were submitted for a twelvemonth to the judgment of the country, they were largely discussed by educational bodies. An influential conference of educationists met and expressed their opinions upon the subject, and from many quarters theoretical and practical advice was tendered to the Government. These various voices were, I think, universally in favour of an extension of scientific teaching; and the above proposals became law in 1882. Geography became a recognised class subject in a much more scientific form than it had previously assumed. There was also added "elementary science," which was defined as "a progressive course of simple lessons on some of the following topics adapted to cultivate habits of exact observation, statement, and reasoning," the topics being "common objects, such as familiar animals, plants, and substances employed in ordinary life," the knowledge becoming more advanced as the child proceeded from standard to standard.

These remain the provisions of the Education Code up to the present date, but public opinion has ripened in the meantime. The large Boards have insisted more and more on object teaching; the London Board immediately revised their instructions to teachers, and put forth a scheme which was more comprehensive than that suggested by the Government. A plan was devised in Liverpool by which the specific subject of Mechanics might be taught by well qualified teachers with good apparatus visiting fortnightly from school to school, the lessons being repeated in the interim by the ordinary teacher of the class. The teaching is of a wider character than that required by Schedule IV. of the code, and this peripatetic system, as it has come to be called, has proved itself very successful, not only in Liverpool but in Birmingham, London, Nottingham and other towns. In many towns also higher grade elementary schools have been established, as for instance in Manchester, Sheffield, Birmingham, Bolton, and Brighton, and these all impart a considerable proportion of science teaching. In the pupil teachers' schools that have been established in London, a course of instruction in natural history and physical science is an essential part of the programme.

But while the opinion of educational authorities has been increasingly in favour of a large infusion of scientific teaching, what do we find has been the actual state of things in the schools? As far as infant schools are concerned no doubt object lessons are usually provided; and the instructions given to her Majesty's inspectors referring to the method of teaching, the provision of little museums of specimens, &c., leave little to be desired, but the time is necessarily greatly restricted by the amount of attention which is requisite in order to satisfy the inspector in regard to reading, and especially spelling. There is a gradual but great improvement in the manner in which geography is taught, and here again the instructions issued by the Department are excellent. The following may serve as a sample:—"Geographical teaching is sometimes too much restricted to the pointing out of places on a map, and to the enumeration of such details as the names of rivers, towns, capes, and political divisions. It is hardly necessary to say that geography, if taught to good purpose, includes also a description of the physical aspects of the countries, and seeks to establish some association between the names of places and those historical, social, or industrial facts which alone make the names of places worth remembering."

Elementary science, however, as a class

subject has gained scarcely a footing in our schools. The cause of this is not want of interest in the subject so much as the action of the code itself. Grants can be obtained for not more than two class subjects, of which English must be one. The consequence is that in boys' schools, if any subject be undertaken beyond English, it is almost sure to be the familiar subject of geography; while in girls' schools the temptation of getting for needlework 2s. as a class subject, instead of 1s. for each girl under Art. 109 (*c*), causes it to displace geography, history, and science. The result will be seen in the following Table, made up from the official returns of the Education Department for England and Wales, for all public elementary schools both Board and voluntary:—

Class Subjects.—Departments.	1882-3.	1883-4.	1884-5.	1885-6.	1886-7.	1887-8.
English	18,363	19,080	19,431	19,608	19,917	20,041
Geography	12,823	12,775	12,336	12,055	12,035	12,058
Elementary Science ..	48	51	45	43	39	36
History	367	382	386	375	383	390
Drawing	—	—	—	240	505	—
Needlework	5,286	5,929	6,499	6,809	7,137	7,424

It is here evident that, notwithstanding the considerable increase in the number of schools, between 1882 and the present time, in which English is taught, there is a slight falling off in the number which teach geography, while the figures for history remain small, and the few departments that took up elementary science are now ceasing to do so.

Nor is the result more hopeful if we turn to the statistics of the scientific specific subjects. The following Table is drawn up in the same way as the preceding, except that it refers to the number of children examined instead of school departments.

Specific Subjects.—Children.	1882-3.	1883-4.	1884-5.	1885-6.	1886-7.	1887-8.
Algebra	26,547	24,787	25,347	25,393	25,103	26,448
Euclid and Mensuration	1,942	2,010	1,269	1,247	995	1,006
Mechanics A	2,042	3,174	3,527	4,844	6,315	6,961
,, B	—	206	239	128	33	331
Animal Physiology	22,759	22,857	20,869	18,523	17,338	16,940
Botany	3,280	2,604	2,415	1,992	1,589	1,598
Principles of Agriculture	1,357	1,859	1,481	1,351	1,137	1,151
Chemistry	1,183	1,047	1,095	1,158	1,488	1,808
Sound, Light, and Heat	630	1,253	1,231	1,334	1,158	978
Magnetism and Electricity	3,643	3,244	2,864	2,951	2,250	1,977
Domestic Economy	19,582	21,458	19,437	19,556	20,716	20,787
Total............	82,965	84,499	79,774	78,477	78,122	79,985
Number of Scholars in Standards V., VI., and VII.	286,355	325,205	352,860	393,289	432,097	472,770

It thus appears that, while the number of scholars in those standards in which specific subjects may be taught has increased from 286,000 to 472,000 during the six years, there is not a single scientific subject, with the exception of mechanics, which shows a similar increase; in that the increase is considerably greater: while in geometry, animal physiology, botany, magnetism and electricity, and the principles of agriculture, there has been a great falling off, not merely in the proportional, but in the actual numbers. Chemistry, and the combined subject of sound, light, and heat, nearly maintain their position. But the rapid and serious decrease of attention paid to these science subjects as a whole is best shown by the per-centage of children who have taken them, as compared with the number of scholars who might have done so, viz. :—

In 1882-3	29·0 per cent.
,, 1883-4	26·0 ,,
,, 1884-5	22·6 ,,
,, 1885-6	19·9 ,,
,, 1886-7	18·1 ,,
,, 1887-8	16·9 ,,

These figures are taken from the last annual Report of the Committee of the British Association on the teaching of science in elementary schools.

To what are we to attribute this state of things? It is no doubt partly due to the fact that few teachers themselves are well prepared for giving instruction in some of these subjects. This fact may account for the difficulty with regard to the teaching of agriculture in England, as it certainly does in France. It may also be that most of these subjects bear an ambitious name, and that, as defined in Schedule IV. of the Code, they are scarcely suited to practical requirements; but another obstacle is probably the present system of payment by results, which induces the teachers or managers of schools to confine their attention to those subjects which they think may be most remunerative on the day of examination.

The difficulties referred to above would have been somewhat diminished if the code which was laid upon the table of the House at the beginning of this year had been accepted and passed into law; but it may be hoped that any future action of the Department in this matter will carry out more fully the admirable recommendations of the Royal Commissioners appointed to inquire into the working of the Elementary Education Acts. Though they differ widely upon other subjects, the majority and minority were equally of opinion that "some elementary instruction in science is only second in importance to the three elementary subjects," namely, reading, writing, and arithmetic; and they place amongst subjects regarded as essential—"geography, especially the British Empire; lessons on common objects in the lower standards, leading up to a knowledge of elementary science in the higher standards."

I would venture to lay down as essential principles—(1) That the knowledge of things as given especially by object lessons, should precede the knowledge of words as given by reading lessons; (2) that this teaching of Nature should have reference mainly to the facts which are within the observation of children, and to those fundamental principles which underlie all natural knowledge rather than to the specific forms of that knowledge which are designated by the names of chemistry, mechanics, or physics; (3) that these object lessons should be continued from the period of the child's entry into school to the time of its leaving the school, becoming however more systematic, and more strictly scientific as they proceed; (4) that this scientific instruction should be considered quite as worthy of attention and encouragement as the literary studies of the school.

TECHNICAL INSTRUCTION.

It has recently been strongly urged that technical teaching should form a part of the instruction in our elementary schools, and should receive grants from the public funds. Theoretical educational reformers have long contended that the hand and the eye ought to be educated, and that the natural activity of a child should be taken advantage of in its practical education. Politicians and manufacturers have contended that the English workman was falling back in competition with other nations, and that the commerce and wealth of the world was leaving our shores in consequence. The kinder-garten system, it is true, unites no small amount of manual instruction and bodily exercise with object lessons, and other kinds of intelligent methods, and this is alluded to no doubt in the "appropriate and varied occupations" of the code of 1882. But the kinder-garten system has been virtually confined to very little children, while technical instruction, properly so called, has been the privilege only of those who are grown up or nearly so. Those who claimed that the gap should be filled, and that the children of our elementary schools should be prepared more or less for subsequent technical instruction, were few in number. Sir Lyon Playfair and others who advocated these views seemed long merely as voices crying in the desert, but suddenly the popular attention was roused to the subject, and we now find ourselves part of a loud chorus of voices. These voices are no doubt very confused; the word "Technical" is used in many different senses; some, too, look upon the matter from the point of view of the education of the individual, others from the economic welfare of the community. A Royal Commission on Technical Instruction was appointed in August, 1881, which reported in 1884, after examining the practice of other nations as well as our own. The London School Board instituted experiments, and the subject has been largely discussed both in our own country and in America. It appears to me that there is a fair consensus of opinion upon the following points:—First, the teaching of trades is no part of the duty of the elementary schools, at any rate not until the standard of exemption is passed. It is evident that in our large classes such instruction must be given as is presumably valuable for every scholar. It is evident too that the workshop is the most fitting place for true technical instruction. Second, that the education of the senses may and should be carried on throughout the school, and lead up to clearness of perception and manual dexterity. This of course would be useful to all, whatever their future occupations may be. For this purpose drawing should be made an essential subject in boys' schools, and perhaps in girls' schools, the drawing being rather of the useful than of the artistic order. Modelling in clay may also be added. The use of tools should also be carefully taught, whether these tools be the pencil or the pen, the scissors, or the chisel and saw. Third, that the scientific principles which lie at the foundation of the useful arts may well form part of the instruction given in the schools in elementary science. Fourth, that to scholars in the ex-Seventh Standard, or in upper grade schools, or in continuation or evening classes, more specialised instruction in the useful arts might be given.

The most important public utterances seem to have tended in this direction. Thus the Royal Commission on Technical Instruction reported as follows:—

"(*a*) That rudimentary drawing be incorporated with writing as a single elementary subject, and that instruction in elementary drawing be continued throughout the standards. . . . . . That drawing from casts and models be required as part of the work, and that modelling be encouraged by grant."

"(*b*) That there be only two class subjects instead of three in the lower division of elementary schools, and that the object lessons for teaching elementary science shall include the subject of geography."

"(*d*) That proficiency in the use of tools for working in wood and iron be paid for as a specific subject, arrangements being made for the work being done, so far as practicable, out of school hours. That special grants be made to schools in aid of collections of natural objects, casts, drawings, &c., suitable for school museums."

A Special Committee on "Subjects and Modes of Instruction," which was appointed by the London School Board, brought out a valuable report, drafted by Mr. Bousfield, with many recommendations, among which may be quoted the following:—

"1. That the methods of kinder-garten teaching in infants' schools be developed for senior scholars throughout the standards in schools, so as to supply a graduated course of manual training in connection with science teaching and object lessons, but not so as to include teaching the practice of any trade or industry; and that the method of kinder-garten in the senior schools be tried at first in a few special schools throughout London.

"2. That the teaching of all subjects be accompanied, where possible, by experiments and ocular demonstration.

"4. That all manual instruction should be given in connection with the scientific principles underlying the work, and with suitable drawing and geometry.

"6. That classes for instruction in Slöjd be established in three selected schools.

"16. That, in order to allow time for experimental teaching and manual work, the time now given to spelling, parsing, and grammar generally be reduced."

The Royal Commission on the Working o the Elementary Education Acts in their still more numerous recommendations frequently refer to such preparation for technical instruction, as for instance:—"The curriculum in the ordinary elementary schools might often include not only instruction in the elementary principles of science, but also in certain standards elementary manual instruction in the use of tools; and in higher schools and evening schools this work might be carried still further."

These principles are also being put into practice. The use of carpentry tools forms part of the instruction in the Seventh Standard school at Birmingham, started by Mr. George Dixon, and perhaps in all the higher grade or central Board schools of the country. A joint committee of the City and Guilds of London Technical Institute and the School Board is also carrying it out, at the expense of the guilds, in six centres with great success. These workshops are attended by children from both Board and voluntary schools; and an important feature of the instruction is that they are taught the nature and history of different woods, and that the carpentry work is done from previous drawings. Equally interesting is what is taking place in Ireland, where in country schools a course of lessons on agriculture, including cottage gardening, is obligatory for all scholars above the third class, and great attention is paid to advanced kinder-garten, and such handicrafts as embroidery, braid work, wood-carving, art needlework, artificial flower making, &c. Experiments are also being tried in various places in advanced kinder-garten, and in the Swedish educational wood-carving known as "Slöjd."

But how does the Education Code affect this manual or technical instruction? In infant schools it may be included under the provision made for appropriate and varied occupations, but there is no encouragement from Standards I. to IV. In Standard IV., however, we find a model scheme of elementary science, including:—

> "(*b*) Substances employed in arts and manufactures.
>
> "(*c*) The simpler kinds of physical and mechanical appliances: *e.g.*, the thermometer, barometer, lever, pulley, wheel and axle, and spirit level."

Then in Standard V.:—

> "(*b*) The chemical and physical principles involved in one of the chief industries of England, among which agriculture may be reckoned.
>
> "(*c*) The physical and mechanical principles involved in the construction of the commoner instruments, and of the simpler forms of industrial machinery."

In Standards VI. and VII.:—

> "The preceding in fuller detail."

In Standards V. to VII. somewhat similar scientific lessons leading up to technical knowledge may be given as specific subjects, especially under the heads of mechanics, principles of agriculture, and domestic economy. We have already seen that the amount of attention paid to these subjects is advancing in regard to mechanics, retrograding in regard to domestic economy, if we compare the number of girls taught with those actually present in the upper standards, and very rapidly retrograding with agriculture. Manual instruction or the use of tools is not recognised as a code subject. It was introduced in the Beethoven-street School, Kensal, four years ago, but the Board was surcharged with the expenses by the official auditor, and this was confirmed by the Local Government Board. The experiment, however, was considered so successful that it was continued by private means, and now the manual instruction class is placed on the time-table with the concurrence of her Majesty's inspector. The Liverpool Board also has lately obtained the opinion of counsel (Sir Horace Davey) that an elementary school may expend money on extra subjects, and experiments have been started in two or three places which will soon decide the legality or otherwise of the proceeding.

With girls' schools the case is different; technical instruction is not only permitted but is obligatory. Needlework is an essential subject, and is taught with all the perfection of a technical art, two afternoons in the week being almost necessarily devoted to it. The practical teaching of cookery receives a grant, though it is not compulsory. The educational value of this teaching is much greater than that of needlework, but 40 hours during the year is all that the Government require or allow, neither more nor less. Domestic economy also, when taught experimentally, has somewhat of the same technical character.

In the meantime, schemes have been put forth by such veteran educationists as Mr. Thomas Twining, and by many others; much more attention has been paid to drawing as the basis of manual instruction; a National Association for the Promotion of Technical Education has been organised, and has published tractates, and held conferences; and at last the subject has engaged the attention of Parliament. Sir Henry Roscoe has for three sessions introduced a Bill for technical education in day schools, which has always passed its first reading, and which would have become law during this year, if he could have accepted some of the modifications insisted upon by the Government. In 1887, Professor Stuart introduced a Bill for evening continuation schools, and Mr. Samuel Smith did the same, both in 1888 and this year, but all were withdrawn. Each year, however, the Government has taken up the subject, but their proposals had to be abandoned in 1887 and 1888, though a Bill for Scotland was carried in the latter year; and at the very close of the last session, a Technical Instruction Act was passed relating to England and Ireland.

This Act was passed in so hurried a manner, after several amendments, that it is not easily understood. It clearly will have little to do with elementary schools, for it does not apply to scholars receiving instruction in the obligatory or standard subjects. It still leaves legislation in its former unsatisfactory state in regard to every point contended for in this paper, such as advanced kinder-garten, manual instruction, and the scientific principles that underlie the useful arts.

Nevertheless, it may be of service for ex-Seventh Standard scholars, or for evening classes. Is it well adapted for this purpose? May we accept it as a fair instalment? The definition of technical instruction seems to be satisfactory. It is as follows:—"The expression 'technical instruction' shall mean instruction in the principles of science and art applicable to industries, and in the application of special branches of science and art to specific industries or employments. It shall not include teaching the practice of any trade, or industry, or employment."

This instruction may be subsidised from local rates to the extent of one penny in the pound; but the local authority that determines whether this shall be so is not the School Board, who are elected for the very purpose of securing the education of the people, but the County or Borough Council, or the urban—and in Ireland the rural—sanitary authority; bodies not generally chosen for any presumed educational fitness. This tribunal, too, may decline to act even when called upon to do so. The local authority has the large option, too, of either forming technical schools itself, or of subsidising out of the rates any schools or institutions which give such instruction. Where a voluntary school is subsidised, a representation of the local authority on its management is prescribed; but it would be a very inadequate one in most cases, and it would practically amount to the expenditure of public money without public control. Any instruction given under this Act will be subject to the general control of the Science and Art Department, and not, as in the Scotch Act of 1887, of the Education Department. This may have some advantages, though it breaks the continuity between the earlier and the later stages of education. The Science and Art Department has not yet indicated the conditions on which Parliamentary grants may be made in aid of such instruction.

In concluding this paper, I should like it to be distinctly understood that I do not claim for scientific or technical instruction any exclusive or even predominant place in the curriculum of our elementary schools. It seems to me that, in the schools common to all children, each child should be dealt with as possessing a physical, intellectual, and spiritual nature, and that its education should be directed in due proportion to science and literature, while also recognising its æsthetic and moral culture. The elementary school should not give, but it should prepare the way for, those more special studies which, in polytechnics, technical schools, and continuation classes, may fit the learner to perform easily and happily all the varied work of life.

DISCUSSION.

Sir PHILIP MAGNUS said he thought all who had carefully considered this subject were pretty unanimous with regard to the importance of introducing science teaching into elementary schools, and such rudimentary technical instruction as had been alluded to. The only difficulty was as to the method of doing so. They all recognised that the system of object lessons should be made the basis of scientific instruction, and that what should be avoided was the mapping out of science into different departments, such as chemistry, physics, physiology, mechanics, &c. On the other hand, they should take the objects, and, working from them, deduce the elementary laws of science which underlay the explanation of the phenomena the children could observe. At the very first stage of science teaching experimental methods should be introduced, and the children should not only see the experiments, but perform simple ones themselves. On this account he was not wholly satisfied with the peripatetic system, because although the teacher brought his apparatus with him, unfortunately he took it away with him when he left. It was very important that the Froebel system should be regularly and gradually pursued throughout all the standards of the elementary schools, as was now generally admitted. Amongst the causes of failure mentioned by Dr. Gladstone was insufficient preparation of teachers themselves. He believed that all teachers should be prepared to teach all subjects, and it should not be necessary to introduce special teachers. The children would have more reliance on the lessons received from their ordinary teachers, and the amount of science which it was necessary that the pupils should be taught, might be learned by elementary teachers just as well as geography, history, or any other subject. In French schools this was the practice, and he might say he was very much struck this year in passing through the gallery of the Exhibition devoted to the display of school work, by seeing the care and attention bestowed on every detail connected with the work of elementary schools, and the enormous progress which had been made in that country within the last few years. When serving as a member of the Royal Commission in 1881-2, he was much struck with the advance made by the French in educational matters. He believed then that they had the very best theory and were prepared to put it into practice, but he was scarcely prepared for the enormous progress they had made since. Among those exhibits were a large number of specimens of work which students in training were required to prepare before receiving their certificates as trained teachers, and among them were chemical preparations, simple apparatus made by their own hands, showing how the physical and mechanical sciences might be illustrated, as well as specimens of wood and iron work. He did not think this was the case in England, but it was very important that the teachers should receive technical training in order that they should be able to impart it to the children. Another thing which had prevented the progress of technical instruction was the system of payment by results. Nothing surprised foreigners so much as this system, and he often found it very difficult to explain, seeing it was different to that which obtained anywhere else. He believed that the system had done a large amount of good, but every one was now prepared to admit that some considerable change must be made if the teaching in elementary schools was to be of an intelligent character. Dr. Gladstone had referred to the interesting experiment performed by the London School Board in connection with the City and Guilds Institute, and anyone who would visit a class in which manual instruction was given would find it very interesting. The Liverpool School Board contemplated introducing this manual instruction into all their schools, and had recently come to London to inspect those schools in which it was adopted, and expressed their satisfaction with the results. He did not think the Act of Parliament of last session would do very much for elementary schools, but still it might be the means of providing funds out of which evening technical schools might be more satisfactorily carried on. They must all hope that it would be regarded as an instalment of something further. Whether the alteration required to secure better science teaching in elementary schools would necessitate another Act, or whether it could be done by alteration of the code, he must leave to politicians to decide, but certainly considerable alterations were needed if elementary schools were to provide that scientific and technical instruction which all were agreed was necessary.

Mr. Bousfield said there was one point in the paper of exceptional significance. Dr. Gladstone commenced by giving an account of the series of attempts which had been made by the Education Department to improve technical and manual teaching by alterations in the code, and by Parliament in appointing various Royal Commissions, and concluded by pointing out their practical effect, and he could not imagine a greater failure. He felt, therefore, that some very great change was required before elementary schools could give that teaching which it was absolutely necessary to give boys who were going to engage in industrial work and to take advantage of subsequent technical education. Those interested in education, therefore, ought to put pressure on the Government and the Department, in order that these changes might be introduced. The education should be continuous from the elementary school up to the time when the boys went to work; but there seemed a tendency to make it a separate thing in every department and every school. The teaching in infant schools was totally different from that in the senior departments. The kinder-garten system was effectually carried out in the infant schools, but it was entirely abandoned afterwards. The principle running through the report of the London School Board was to take the kinder-garten and develop it onwards, never losing sight of the fact that the boy or girl had to deal with things as well as with words. He was glad to find that the teachers took a cordial interest in this question. One of the inspectors was giving a series of lectures in different parts of London on the method which had been adopted for developing the kinder-garten, and he was recently present in Chelsea at a crowded meeting of teachers, who took the greatest interest in learning from Mr. Rix how to use their own fingers in order that they might teach the children to use theirs. The City and Guilds Institute had also been giving instruction to teachers in wood working, and for several years there had been more applications than there was room for. It was all the more pity that scarcely any manual or technical training was given in the training colleges; and he hoped that if any change were made in the code some form of manual instruction would be insisted on in the curriculum of these colleges, as well as in the schools. In the new scheme of the Charity Commissioners for dealing with the City endowments, no provision had been made for the School Board being represented on the Board of Management of the new polytechnics which were to be created; he understood these establishments were to form an intermediate link between the elementary schools and the higher technical schools, such as those established by the City and Guilds Institute, and therefore both those bodies ought to be represented in the management, otherwise there would be no regular scheme of instruction taking the children on from one stage to another. In addition to what Dr. Gladstone had said about the manual instruction given to girls, he should like to mention that at the present time a scheme for teaching laundry work was being carried on by the London School Board in connection with the City and Guilds Institute. At first sight it might be thought that this was hardly an educational subject, but those who studied the syllabus would see that it was exceedingly educational, both manual and mental. He was present recently at the William-street School, Kensington, when instruction was being given to a number of children, both in theory and practice, and in a very few lessons they had gained considerable knowledge of many things it was necessary for a girl to know. The teachers also expressed their great appreciation of the intelligence which this teaching was calculated to impart, and some books of notes taken by the children were exceedingly creditable. This kind of teaching was commenced in Liverpool, and had been going on for some time there very successfully. Whatever was done in the future, the necessity of one continuous system of education should be borne in mind. With reference to the new Act, he much regretted that the School Boards were not made the authority to carry it out, as they were much better fitted for it than either town or county councils. It would improve the *personnel* of many School Boards if those interested in secondary education were attracted to act upon them, and as they were in possession both of the buildings and the machinery necessary for carrying out primary technical instruction, they should have charge of the matter. He had seen a letter from Sir Henry Roscoe, in which he said he had been informed by the Education Department that it would be impossible for the authority levying the penny rate for this purpose to apply any of it to instruction given under School Boards. He believed the Evening Classes Committee of the London Board had determined to start several evening schools, and to ask the County Council for aid in giving technical instruction in them, but if the reply given to Sir Henry Roscoe were correct, they would not be able to get such assistance. To put intermediate education under a totally different body from that which had to do with primary education must be a mistake, and he hoped that, amongst the changes which it was admitted were necessary before this Act could be of much benefit, this would be borne in mind.

Mr. ALFRED WIRE (Head Master of Harrow-green Board School) said he came expecting to hear a theoretical paper, and was exceedingly gratified to find that it was so practical. He had had some 30 years' experience in teaching. He might say that he had taught drawing not only in town but in the country, to a whole school, but the action of the Department was not so encouraging in this direction as formerly. About a month ago he presented 439 boys. When the report was received, the school was marked excellent, but only eleven boys in the upper standard got certificates, which were simply a disgrace to an Art Department, and no one a prize. The boys were naturally rather disheartened. The figures in the tables were rather startling, but they did not show the real state of science teaching in the country, for there was a great deal going on of which the Government took no cognisance. He was very fond of science teaching, and so were many others. He had been in his present school nearly thirteen years, and during the whole of that time he had given object lessons, such as had been described, but no inspector ever took the slightest notice of them until this year, when there was a fresh inspector. His object was not so much to qualify boys to pass an examination as to give those principles of science which underlay the constructive arts, especially electricity, magnetism, chemistry, and mechanics. One of his boys told him that one evening when he went home, after a lesson on electricity, he told his father what he had learned that he could get sparks from a piece of india-rubber and brown paper; the father would not believe it, but the litttle boy carried out the experiment, and got some sparks, and he said his father stayed at home the whole evening trying it again and again. There was no doubt a difficulty with regard to teaching, for many young persons became teachers who were but ill-qualified, and who had not the opportunities there were in London for making up their deficiencies. He was not able to give to his science teaching as much time as he should like, and he hoped that in a future code some better provisions would be made on this subject. As a rule, science teaching met with no encouragement at the hands of the inspectors. He had had the walls of his school covered with drawings, or with maps which the boys had coloured, only to be told—"I do not understand drawing; or—"You will not get any credit for that; it is not in the code."

Professor AYRTON, F.R.S., said he was particularly interested in the tables showing the falling-off in the number of children studying subjects which during the same time had been steadily increasing in national importance. He referred specially to electricity and magnetism, for it would soon be difficult to find an industry in which a knowledge of these subjects was not necessary. If the present system went on, of large payments for bad results, or, it might be, of incompetent teachers, a few years hence, when everybody was using electricity to do everything, children would know nothing whatever about it. Amongst the work done by the City and Guilds Institute which had not been mentioned was the instruction given on Saturdays in wood-work, and also in other subjects on the list. After Christmas there would be a course, at almost nominal fees, for elementary teachers, in magnetism and electricity. Dr. Gladstone had referred to the difficulty of defining technical education. He himself did not think it meant sciences applicable to industries, for as far as he knew all science was so applicable; it was rather as defined in another clause, "the application of special branches of science and art to specific industries and employments." Dr. Gladstone said the workshop must be the place for true technical education, but he certainly differed from him entirely. The workshop was just the place where, at the present day, you could not get technical education. There was no organisation in any factory he knew of for training men. The business of a factory was to turn out machinery as cheaply and as well as they could turn it out; but as a man did not happen to be a saleable commodity, there was no time, thought, or money devoted to fashioning that article. There were two students now at the Central Institute, one of whom had been four years in a factory in America, and the other had just finished a five years' apprenticeship in an electrical factory in England, and they knew nothing of the application of the sciences of electricity and magnetism to electrical engineering, and they were, therefore, just beginning their technical education. It was desirable to avoid a loose use of the word technical; especially just now when an effort was being made to create certain educational establishments, by the aid of private munificence and State assistance, which were to be called "polytechnics." This name was probably taken from the establishment in Regent-street, where no doubt good educational work was now being done, but not at all of the character attaching to polytechnics on the Continent, where a much higher class of teaching was afforded than would be given in those about to be established in London. It would only be by as high a standard of teaching, not by calling an inferior establishment by the same name, that our young men could hope to compete with the highly-trained polytechnic students abroad. The definition of technical education seemed to be given very clearly in connection with Standard V.—"The teaching of the sciences which underlie some special industry of importance to the country." It was highly important to teach boys and girls the use of tools, and all technical students must go through that training; but people must not imagine that when they had learned the use of tools they had been technically educated, any more than when any one had learned to write with a pen he had acquired literary ability.

Mr. Trewby thought that in giving marks to children some allowance ought to be made for special subjects. Many children took an interest in drawing who could not go far enough to obtain certificates, and marks in such cases ought to be added to their general aggregate, or else teachers would not persist in teaching children who were not successful enough to pass. He knew that in a great many schools they were going to give up teaching drawing in the class-room, because there were not children enough to occupy it. If allowance were made in the marks, then the teachers would be willing to continue it.

Mr. Lant Carpenter remarked that there was a great reduction in the number of children receiving scientific instruction, amounting to no less than 41 per cent., and Dr. Gladstone had drawn a distinction between two modes of teaching—by means of books and things. He had also told them that in certain large towns there was a special method of teaching which was particularly practical in its character, in which things rather than words were taught. Could he say whether in those places the number of children taking these subjects had increased, or had they shared in the general reduction.

Mr. Beaumont Morris said he was vice-chairman of a School Board in Kent, just outside of London, in a district which included a great many engineering and other establishments. There was no machinery in connection with that School Board for educating the children in such a way as would fit them to enter these establishments, and, consequently, on leaving school, they had to find employment in other parts of the country, whilst strangers were brought into the district in their place. If power had been given by the recent Act for the School Boards to levy the rate for the purpose of getting the necessary machinery, much good might have been done, but he feared the local authorities would not be likely to set the Act in motion.

Mr. Christy wished to corroborate the remarks of Mr. Wire. According to the figures in the table, botany had fallen off over 50 per cent.; but he could speak for the excellent manner in which that subject was taught at Sydenham by Mr. Dibley. He carefully prepared his scholars, taking them into the country and explaining the subject to them thoroughly; and several gentlemen attended his classes with a view of passing the examination of the Pharmaceutical Society. But when the report came out from the Government inspector, some who had studied very carefully were never mentioned at all, and others who had given up the subject as too difficult got prizes; the whole thing was a *fiasco.* It became quite a scandal, and people said if there were to be such inspectors it was no use taking up the subject.

Mr. Pring said he was a teacher in an endowed school. He thought the figures did not indicate a decline of interest in science teaching either on the part of parents, teachers, scholars, or managers, but one article in the code explained the whole matter. Up to 1883 children in the Fourth Standard were allowed to take specific subjects, but in 1884 another regulation was introduced, restricting those subjects to the Fifth and Sixth Standard. But the children in the Fourth Standard far outnumbered those in the other two together. Much had been said of the inability of teachers to teach science subjects, and in many instances it was so, but they were not given a fair chance. The peripatetic system should be given up. It caused a great want of interest, and put a slight on the hundreds of men who were quite as able to teach as the peripatetic teacher. In the London Board schools there were scores of young men who had qualified themselves by years of study and practice, giving up their evenings to attend classes, but they were not allowed to teach science because the peripatetic teacher came round to do it. There were assistant teachers who had taken a B.Sc. degree at London University who would be delighted to teach these things, but they could not on account of this regulation. There were some head-masters, trained in a by-gone time, who were not fitted for this duty, but they would be willing to let the assistants do so, and so give them a better position if the rules of the Board allowed it. The head-masters also were willing to learn; he knew some who had grown grey in the work who were now studying science subjects to qualify themselves to teach. This could be seen by the numbers who flocked to the schools of science to learn. He could speak in the highest terms of the good done by the Science and Art Department, which every year allowed teachers to come and take a course of instruction under the ablest men of the day, in order to fit them for teaching science, but they could not find room for all the applicants, who gave up their summer holidays for the purpose. Give the teachers a chance, and there would be no complaints of a lack of science teaching in England.

Mr. JOHN LEIGHTON said that Dr. Gladstone's admirable paper led him to venture a few remarks upon one phase of technical education, grounded on the experience of nearly half a century. Writing and linear drawing, which is but a phase of it, were important, but refinement of the touch, eye, and ear might be carried too far, especially if it displaced the practical. Pen and pencil should be the only tools used in elementary schools, the brush and the stylus being avoided. Modelling should form no part of elementary education. All teachers should be able to draw diagrams upon a black board, such as a clock face, a thermometer, &c. Painting, practice with wet clay, and tools of all sorts, seemed to him to be beyond the Board school, and to be the province of the technical institute. The Board school should give all that was elementary, the technical institute all that was creative.

The CHAIRMAN, after saying a few words on behalf of inspectors of schools, who were not supposed to take part in public discussions, and who were therefore not able to defend themselves, but who as a class discharged their onerous duties in a conscientious and effective manner, said the effect of the paper and discussion was to impugn our whole educational system. Twenty years ago, he was engaged with Mr. W. E. Forster in formulating the Act which redeemed England from the stigma of being the most grossly ignorant of any Protestant country in the world. They had first to cover the ground, and bring the children into the schools—to provide quantity—but in future they must turn more attention to quality. Those who best knew the position of education in this country, knew best how miserable it was compared to that of other nations. No man, however scientific, could put a quart into a pint pot, but it was what many seemed to be aiming at. At what age did children leave school? In 8,000 parishes, the Fourth Standard was a total exemption when the children had to go to work, and many left school without attaining even that. That was not even the barest elementary education. The better the teacher and teaching appliances, the sooner the child reached the Fourth Standard, and where these low standards were fixed by the local authorities, the children were passing out of the schools earlier and earlier every year. At the Fourth Standard you had the maximum number in school, there was a heavy drop to the Fifth, at the Sixth a still greater, and at the Seventh zero; and yet they were talking of scientific and technical instruction in elementary schools. The whole system required to be re-cast. Unless the teacher could calculate on having the child for a certain number of years, and the schools were graded to deal with the children accordingly, they could not hope even for success in the barest elementary subjects. No other country which had a system of compulsory education spent anything like so much with so little profit. He might be asked, having been Vice-President, why he did not manage things better? The answer was, that up to now the great object had been to bring the children into the schools. Mr. Forster had once said to him, when he remarked on the number of children passing out at the third grade, that he was glad to accept any standard from the local authority in order that the children might get a chance of passing something. The first thing he did in 1880 was to get bye-laws for the whole kingdom, and in that year he got an Act passed requiring that every local authority should have bye-laws, and that no child should be employed who did not pass the standard thereby laid down, but he had great struggles with some local authorities to get the standard for half time above Standard I., there was a district in the neighbourhood of Liverpool where that was still the standard, and there were a few districts where Standard III. was the standard of full time. With such a system the children, by the time they were 13 or 14, had forgotten all they had learned, and it was no wonder that elementary science had gained no footing. Still there had been great progress in the large towns, especially in the higher standards; the numbers were constantly going up from the fifth to the seventh, but he believed the progress in science teaching had not kept pace with that growth. As Mr. King had said, up to 1883 the code provided that specific subjects might be taught in the Fourth Standard, and there were lots of children of ten or eleven passing in what were called specific subjects, such as physiology and all sorts of grand names, who had not the faintest idea of what those sciences really meant. It was mere cramming to add to the grant, and acting on the advice of the best men he could consult, it was decided that those subjects should not begin unti the Fifth Standard. The whole system was wrong from top to bottom, and wanted re-casting. The children ought to be kept at school at least until they were 13. No German child could leave school until his 14th year, and then he must have continuous schooling for two or three years, and in Switzerland it was carried even further. It was absurd to expect the English master, who had children passing out at ten and eleven, to compete with German, Swiss, and French teachers, who kept their children two or four years later. He agreed that payment by results was a bad system; it was an exclusively English system, and he defied the best friends of education to devise a code which paid so much per subject which did not stimulate cramming. The teacher naturally taught that which paid him best, and which he could teach easiest, and the teacher would always beat the code. He was obliged to; a school manager would say, "The last teacher earned 21s. per head, and you have only earned 20s. 10d.; you do not make as good a show, although you may be teaching much better, a greater variety of subjects, and it may be much more durably." The man who crammed best was the one most esteemed, and he did not see what was to be the cure so long as the money was paid into private hands. The only way was that the whole amount should be paid to the local authorities, and if any school were bad the local authority should be fined; in that way the schools would be kept up to the mark. At the present time a vast proportion of school managers were trying to carry on with a minimum staff, and, with the smallest possible expenditure, endeavouring to make both ends meet without sending the hat round to subscribers. That was not a rational system of education, and so long as it continued so long would these miserable results be shown. Even those bodies which were anxious to do good work were not permitted. Mr. Bousfield had presented a splendid report to the London School Board, which had control of the Metropolis, including something like one-sixth of the population, but they were not even allowed to give a little manual instruction; and when an attempt was made, the public auditor surcharged them, and was supported by the Local Government Board, so that they had to sue almost in *formâ pauperis* to get off the payment of a fine in their endeavour to give a little good education. He thoroughly agreed with the condemnation of the new Act which had been expressed by Mr. Bousfield, but he was thankful for small mercies, and did not want to say more against it than had been said by Sir William Hart Dyke himself, viz., that the measure was not exactly what he should like to have passed, and that it did not touch the large field covered by the elementary schools. Amidst a great deal that was obscure there was one thing, and one thing only, which was quite clear, viz., that the local authority should not out of local rates supply or aid the supply of manual or technical instruction to scholars receiving instruction in elementary schools. Not a shilling therefore was to go for the advantage of elementary school children. That seemed to him like an educational ladder with all the lower rungs knocked out. A meeting had just been held in Manchester to consider this subject, and he could only say he hoped it would be construed in such a way as to turn it to the best account until they could get a better. He had been much pleased with the remarks both of Mr. Wire and Dr. Lant Carpenter. It was quite true that the Science and Art Department could not find room for the teachers who desired to come up. It had taken years of pressure on the Treasury to get them to consent to erecting sufficient buildings to instruct those who desired to become teachers of science, and he had seen them working in lobbies and passages, and all sorts of places, because they could not get proper buildings. This was now being remedied, and that department would become of more service to the teaching of the country. A few weeks ago he was in Paris, and examined what had been done in France during the last eight years; and he knew nothing so marvellous in all his educational experience. The last year of the Empire the Budget for public instruction was 33,000,000 francs (£1,320,000); in 1888 it was 135,000,000 francs (£5,400,000) for teaching alone. In France education was compulsory from end to end. There was a Minister of Public Instruction, whose duties were not confined merely to elementary education, but the latter was complete from the *école maternelle* up to the University. No child could leave the primary school until he was 13, or had received a certificate of having completed the course of instruction. In all primary schools drawing was taught, and modelling in clay, and with great advantage. Then there were the superior elementary schools, between the primary and secondary, and here more advanced scientific and manual instruction was given, there being one continuous curriculum throughout. There were a few of this class of schools in England; he recently opened at Norwich the 52nd, but in France 700 had been called into existence in eight years, and they were increasing every year. After these came the *école professionelle*, which meant practically trade schools, and splendid schools they were, and all these were free. Then came the secondary education, which cost £4, £5, or £6 a-year. All this was a modern creation, but there were now no children passing out at nine or ten in the Third and Fourth Standards. That might be called an ideal, but seeing it was being carried out in France, he considered it a disgrace to England to be below any other country in the matter of education. The material in England, both teachers and children, was as good as any in the world; it only wanted a properly organised system, and it was high time it should be provided.

Dr. GLADSTONE said there was no doubt that France had gone far ahead of anything we were doing.

In reply to Mr. Leighton, he would say that if they were to follow nature, children saw everything in colours, and in order to teach a little child drawing in outline he had first to be trained to recognise outlines in black and white, which were different to anything he saw. If they could only put a brush into his hand instead of a pencil, it would seem theoretically the best, as he could then imitate what he actually saw; but practically this was not found feasible, because a little child made a great mess with the colours, which all ran one into the other unless the outlines were first drawn. Theoretically, the brush ought to come before the pencil, and practically it should be introduced as soon as possible. Modelling also was very useful, and was more natural than drawing, inasmuch as a child regarded objects in three dimensions, not in two only. Children at play did not make drawings on the pavement, but mud pies, which was the first step in modelling. Fröbel's great principle was to follow nature in all these matters, to find what children most easily understood, and use their instincts to lead them on to a good education. With reference to the table and Mr. Pring's remarks, he must point out that no fourth class children were included in the 29 per cent., but no doubt for the first two years there was the influence of the Fourth Standard children who had formerly taken these subjects and continued them when they reached the Fifth and Sixth, and to some extent still further in the traditions of the schools. The peripatetic system had been referred to by more than one speaker; he was very glad that it had been introduced in Liverpool, and taken up in London, as it had done great good, but it was by no means a perfect system, and was not intended to be permanent. It was a means of introducing science teaching, it created a taste for it in the minds of both children and teachers, and the very fact that so many teachers were qualifying themselves to teach science was, in great measure, due to this system having been introduced. When it was found that the head master or teacher was able to take up and carry on the work, the peripatetic teacher was sent somewhere else, and that had been the case in several of the London Board Schools. At first it was found difficult to get head masters to accept this kind of teachidg, but in response to a recent circular 60 head masters had expressed their desire for it, so that it was becoming popular. He quite agreed that the thing to be aimed at was the teaching of science by the ordinary school teachers everywhere. The teaching was demonstrative, if not experimental, and the Board made a grant of £5 worth of apparatus to every school which accepted this teaching, which apparatus was used by the teachers, and, he hoped, by the children also. In reply to Mr. Carpenter, he would say that he believed that where practical science teaching had been given, the interest in it had increased, and also the general intelligence of the school. One of the special subjects had much increased of late years, and that was one taught by the peripatetic teachers, viz., mechanics. He would rather see science taught as a class than as a specific subject, and no doubt a large amount of good science teaching was going on which was not recorded. In process of time, he hoped such changes would be made, either in the code or in the regulations, as would enable it to be introduced much more largely. The use of tools he termed manual, not technical, instruction, and he thoroughly agreed in the view that the whole system of instruction should be continuous from beginning to end. Having drawn attention to the drawings and specimens of wood work which were exhibited, executed in London Board Schools, he said it was still a moot point how far the recent Act could be taken advantage of by elementary schools. It was clear that it could only be above the Seventh Standard. He should rather see it confined to secondary education, where it would serve a useful purpose, and that such regulations should be made in the code as would provide for manual and rudimentary technical education being introduced into all elementary schools.

The proceedings concluded with a cordial vote of thanks to Dr. Gladstone.

Correspondence.

STATE AND FREIGHT.

Recent papers from Budapest give the result of the reduced fares which, under the name of "Zone-tariff," began on the 1st August.

It appears that the daily average of travellers has risen from 14,860 to 36,530, and that the three months' receipts for passengers and their baggage are about £44,000 greater than in the corresponding period of last year. Apparently, the nett result has yet to be reported, but the great experiment promises well.

In the event of national credit being employed for the experimental reduction of Irish railway charges, may not goods traffic merit even more attention than passenger fares?—the State finding some of its requital in the tax-yield of industries thus stimulated.

WALTER M. T. CAMPBELL.

Edinburgh, N.B.,
November, 25, 1889.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings. at Eight o'clock:—

DECEMBER 4.—ARMAND RUFFER, M.A., M.D., "Rabies and its Preventive Treatment."

December 11.—H. Trueman Wood, M.A., Secretary to the Society, "The Paris Exhibition." Sir Philip Cunliffe-Owen, K.C.B., K.C.M.G., C.I.E., in the chair.

December 18.— Sir Robert Rawlinson, K.C.B., "London Sewage."

Cantor Lectures.

Courses of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

William Jago, F.C.S., F.I.C., "Modern Developments of Bread Making." Four Lectures.

Lecture II.—December 2.—*Yeast and Fermentation.*—Yeast, nature of, and functions in bread-making.—Aëration.—Action on albuminous matters. Brewers' and bakers' patent yeasts largely replaced by compressed distillers' yeast.—Properties of each variety, including effects on colour, flavour, volume, &c., of the bread.—Relative strength or fermenting power of each. Foreign and British condensed yeast factories.—Future development of British yeast trade.—Bearing of Hansen's researches on pure yeast cultivation on bread-making.—Salamon's Cantor lectures on "Yeast."—Properties required to produce a perfect bakers' yeast.—Outline of yeast-testing.—Microscopic examination.—Determination of strength.—Yeast adulteration.—Conditions which affect the behaviour of yeast in dough.—Sour bread, causes and remedies.

Juvenile Lectures.

Two Juvenile Lectures, on "The Story of a Flame," will be given by Professor Vivian B. Lewes, on Wednesday evenings, January 1 and 8, 1890, at Seven o'clock.

MEETINGS FOR THE ENSUING WEEK.

Monday, Dec. 2...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. William Jago, "Modern Developments of Bread-making." (Lecture II.)

Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.

Engineers, Westminster Town-hall, S.W., 7½ p.m. Mr. Perry F. Nursey, "Fox's System of Solid Pressed Steel Wagon Frames."

Chemical Industry (London Section), Burlington-house, W., 8 p.m. Mr. Watson Smith, "Some Notes on Variations in the Products of the Destructive Distillation of different Gas Coals, heated separately in the same retort, and under similar conditions." 2. Mr. I. Hauff, "Cresontinic Acid and its Applications."

British Architects, 9, Conduit-street, W., p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

Victoria Institute, 1A, Adelphi-terrace, W.C., 8 p.m. Dr. C. Collingwood, "Instinct and Reason."

London Institution, Finsbury-circus, E.C., 5 p.m. Prof. J. W. Judd, "The Growth of Crystals in Rocks."

Tuesday, Dec. 3...Civil Engineers, 25, Great George-street, S.W., 8 p.m.

Pathological, 20, Hanover-square, W., 8½ p.m.

Biblical Archæology, 9, Conduit-street, W., 8 p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. F. E. Beddard, "The Anatomy of Burmeister's Cariama *(Chunga burmeisteri).*" 2. Mr. G. W. Butler, "The Relations of the Fat-bodies of the Sauropsida." 3. Mr. G. A. Boulenger, "List of the Reptiles, Batrachians, and Freshwater Fishes collected by Prof. Moesch in the district of Deli, Sumatra."

Wednesday, Dec. 4...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. Armand Ruffer, "Rabies and its Prevention."

Geological, Burlington-house, W., 8 p.m. 1. Mr. R. Lydekker, "Remains of Small Sauropodous Dinosaurs from the Wealden." 2. Mr. R. Lydekker, "A peculiar horn-like Dinosaurian bone from the Wealden." 3. Mr. R. N. Worth, "The Igneous Constituents of the Triassic Breccias and Conglomerates of South Devon." 4. Capt. A. W. Stiffe, "Notes on the Glaciation of parts of the Valleys of the Jhelm and Sind Rivers in the Himalaya Mountains of Kashmir."

Entomological, 11, Chandos-street, W., 7 p.m. 1. Mr. Frederic Merrifield, "Systematic temperature experiments on some Lepidoptera in all their stages." 2. Mr. Charles J. Gahan, "Notes on Indian Longicornia, with Descriptions of New Species." 3. Dr. D. Sharp, "The peculiarities of the terminal segment in some male Hemiptera." 4. Mr. Lionel de Nicéville. "Notes on a Species of Lycænida."

Archæological Association, 32, Sackville-street, W., 8 p.m.

Obstetrical, 53, Berners-street, W., 8 p.m.

Thursday, Dec. 5...Royal, Burlington-house, W., 8½ p.m.

Antiquaries, Burlington-house. W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Mr. G. Massee, "Life History of a Stipitate Freshwater Alga." 2. Mr. G. Sim, "The Anatomy of the Sandgrouse."

Chemical, Burlington-house, W., 8 p.m.

London Institution, Finsbury-circus, E.C., 6 p.m. Mr. Henry Power, "Recent Work on Moulds and Mildews."

Numismatic, 4, St. Martin's-place, W.C., 7 p.m.

Archæological Institution, 16, Burlington-street, W., 4 p.m.

Friday, Dec. 6...Geologists' Association, University College, W.C., 8 p m. Conversazione.

Physical Science Schools, South Kensington, S.W., 5 p.m.

Physical Society of London, 176, Haverstock-hill, S.W., 5 p.m. 1. Mr. Shelford Bidwell, "The Electrification of a Steam-jet." 2. Prof. S. P. Thompson, "Notes on Geometrical Optics." 3. Mr. C. H. Caras-Wilson, "The behaviour of Steel under Mechanical Stress." 4. Mr. F. B. Hawes, "A Carbon Point in a Blake Telephone Transmitter."

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FRIDAY, DECEMBER 6, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

The second lecture of the course of Cantor lectures on "Modern Developments of Breadmaking," was delivered by Mr. William Jago, F.C.S., on Monday evening, 2nd inst., when the subject of yeast and fermentation was specially dealt with.

The lectures will be printed in the *Journal* during the Christmas recess.

APPLIED ART SECTION.

A meeting of the Committee of the Section of Applied Art was held on Wednesday, 4th December, at 4.30 p.m. Present: — Sir George Birdwood, M.D., K.C.I.E., C.S.I., in the chair; T. Armstrong, Prof. A. H. Church, Lord Alfred S. Churchill, C. Purdon Clarke, C.I E., Lewis F. Day, General Donnelly, C.B., J. Starkie Gardner, J. Hungerford Pollen, Vincent Robinson, R. Phené Spiers, with H. Trueman Wood, Secretary of the Society, and Henry B. Wheatley, Secretary of the Section.

The programme of papers to be read during the present Session was discussed.

Proceedings of the Society.

THIRD ORDINARY MEETING.

Wednesday, December 5, 1889; Sir Joseph Lister, Bart., F.R.S., D.C.L., LL.D., in the chair.

The following candidates were proposed for election as members of the Society:—

Bromley, Walter Brandreth, Crofton-house, Lampton-road, Hounslow.
Galloway, Earl of, K.T., Cumloden, Newton Stewart, N.B.
Lake, William Robert, 45, Southampton-buildings, Chancery-lane, W.C.
McBean, Alexander, 2. Devonshire-terrace, Portland-place, W.
Portman, Viscount, 22, Portman-square, W.
Raven, Henry Baldwin, 139, Temple-chambers, Whitefriars, E.C.
Sangster, Arthur, 12, College-crescent, South Hampstead, N.W.
Stephens, T., 1, Cuba-street, Millwall, E.
Symes, James Page, 74, Lewisham High-road, S.E.
Thorpe, Harry, 59, Theobald's-road, W.C.

The following candidates were balloted for and duly elected members of the Society:—

Baldry, William Frank, 27, St. Oswald's-road, West Brompton, S.W.
Barlow, Crawford P., 2, Old Palace-yard, S.W., and Deene, Tooting Bec-road, Streatham, S.W.
Bishop, Henry, 41, Coleman-street, E.C.
Blease, Robert Stanley, Ashburn-lodge, Fairfield, Liverpool.
Bolton, Herbert, 28, Regent-st., Bacup, Lancashire.
Bourke, Walter Longley, Westbrook, Eccles, Manchester.
Bugby, William, Gas Works, Southall, Middlesex.
Burford, Samuel Francis, Eastleigh, Queen's-road, Leicester.
Carpenter, George, 12, DeCrespigny-park, Denmark-hill, S.E.
Carpmael, Ernest, 3, Harcourt-bldngs., Temple, E.C.
Chapman, Samuel, 5, Elm-villas, Loughton, Essex.
Coddington, John George Thornton, Ballinasloe, Ireland.
Collis, Thomas James, 116, Cannon-street, E.C.
Congreve, Hubert 4, Witney-ter., Bowdon, Cheshire.
Cooper, William, The Strand, Derby.
Cripps, Frederick Southwell, Clyde-house, Benhill-street, Sutton, Surrey.
Cuvilje, Oswald Bruce, 68, Upper Berkeley-street, Portman-square, W.
Dauber, Henry, junr., 7, Devonshire-place, Portland-place, W.
Davies, David Evan, Rhianfa, Pwllheli, North Wales.
Davies, Thomas, 1, Lombard-court, E.C.
Donaldson, Hay Frederick, Poplars, Bebington, Cheshire.
Dredge, James, 35, Bedford-street, Strand, W.C.
Easton, John Marshall, Redholm, Helensburgh, N.B.
Elgar, Prof. Francis, LL.D., The Admiralty, Whitehall, S.W., and 101, Inverness-terrace, W.
Fairholme, Captain Charles, R.N., 18, St. Dunstan's-hill, E.C.
Findlay, George, Euston Station, N.W.

Forbes, John, M.R.C.P., F.R.C.S., 8, Johnstone-street, Bath.
Golby, Frederick William, 54, Fleet-street, E.C.
Gray, Alexander, 25, Greenhill-road, Hampstead, N.W.
Hart, Thomas, Yewbarrow, Grange-over-Sands, Lancashire.
Henderson, George William, 17, Chesham-place, S.W.
Hoey, David George, Commercial Bank-buildings, 8, Gordon-street, Glasgow.
Holt, Robert Burbank, 10, Bedford-place, Russell-square, W.C.
Hooley, Cosmo Charles, The Union Offices, Patricroft, Manchester.
Hutton, Herbert Ansted, Merlewood, Chislehurst, Kent.
Innes, Lieut.-General James John McLeod, V.C., 9, Lexham-gardens, Kensington, W.
Innes, James William, 4, Tokenhouse-buildings, E.C., and Cheltenham-square, Harrogate.
Jackson, John, 17, Victoria-street, Westminster, S.W.
Jardine, Mrs., 51, Lancaster-gate, W.
Jewell, George Beer, Easton-terrace, Yeovil.
Jones, Arthur Daniel, Engineer's-office, Surrey Commercial Docks, Rotherhithe, S.E.
Kapteyn, Albert, Canal-road, King's-cross, N.
Lancaster, John, Anfield-house, Leamington.
Lindsay, Thomas Steven, 4, Oak-hill-park, Frognal, Hampstead, N.W.
Livsey, John Edward, 34, Octavia-street, Battersea S.W.
McIntyre, Matthew, R.N., 68, Crofton-road, Camberwell, S.E.
Manson, Frederick William, 36, New Broad-street, E.C.
Marshall, Percy Edward, 25, College-hill, E.C.
Matthews, Charles P., J.P., The Bower-house, Havering, Essex.
May, William Holmes, 14, Queen Victoria-street, E.C., and Nutfield-house, Balham, S.W.
Mège, Roch Raymond, 9, Spring-gardens, S.W.
Miller, Thomas Robson, Westminster Palace Hotel, S.W.
Mortimer, John Robert, Driffield, Yorkshire.
Mosley, Colonel Paget, 27, St. James's-square, S.W., and Carlton Club, S.W.
Moxon, Charles Frederick, Beach-cliff, Westgate-on-Sea.
Mudd, Thomas, Hartlepool.
Myring, Jacob, 13, Marlborough-road, St. John's-wood, N.W.
Nunn, Francis Crumpton, Eastnor, Sydenham-hill, S.E.
Orrock, James, 48, Bedford-square, W.C.
Papworth, Wyatt, 33, Bloomsbury-street, W.C.
Payne, John Bruce, M.A., Cloford-house, Kirkley-cliff, Lowestoft.
Petre, Lord, 21, Hyde-park-gardens, W., and Thorndon-hall, Essex.
Platt, James, Somerset-villa, Gloucester.
Praed, Fitzpatrick, 73, Eccleston-square, S.W.
Provis, Thomas Bawden, 76, Finsbury-pavement, E.C.
Quick, Frederic William, 510, Mansion-house-chambers, E.C.
Rait, George Thomas, 70, Bishopsgate-street within, E.C.
Rooper, Henry Napier, 17, Lincoln's-inn-fields, W.C.
Rust, Arthur, Eversleigh, Leicester.
Smith, John, 8, Old Jewry, E.C., and 346, Camden-road, N.
Smith, Sidney Robert James, 15, York-buildings, Adelphi. W.C.
Smithe, William Arthur, B.A., 53, Wool Exchange, Coleman-street, E.C., and 39, Elm-grove, Cricklewood, N.W.
Spain, Harry George Guthrie, St. Thomas, West Indies.
Steel, John, Cheribon, Preston-park, Brighton.
Stiff, William Charles, Credenda Seamless Steel Tube Works, Ledsam-street, Birmingham.
Stocker, Alonzo Henry, M.D., Peckham-house, Peckham, S.E.
Straker, Sidney, 240, Stanstead-road, Forest-hill, S.E.
Sykes, George Henry, M.A., 12, Albert-square, Clapham, S.W
Taylor, Jonas Dearnley, Springfield, Halifax.
Thomson, Charles Skeldon, B.Sc., Ormskirk, Durham-road, Cottenham-park, Wimbledon.
Thomson, John Millar, King's College, W.C.
Towler, Alfred, 31, Bismarck-street, Beeston-hill, Leeds.
Vaughan, James, 40, Gloucester-terrace, Hyde-park, W.
Weyman, James Edwardes, Church Acre Iron Works, Guildford.
White, Henry Watkins, 122, Lavender-hill, S.W.
Wilshire, Ruthven Matcham, 57, Stephanien-strasse, Carlsruhe, Germany.
Woodall, John Woodall, M.A., J.P., St. Nicholas-house, Scarborough, Yorks.

The Chairman, in introducing Dr. Ruffer, said, that as a member of the Parliamentary Committee, it was his business to sift very carefully the evidence which M. Pasteur brought forward in support of his preventive treatment of rabies, and the result with him, as with every member of the Committee, was that he was thoroughly satisfied on the subject. He had also visited the Pasteur Institute, and had seen with admiration the perfection of the equipment of the Institute, and the thoroughly scientific manner in which the operations were conducted. He also knew M. Pasteur's kindness of heart, and his especial tenderness towards suffering, whether in man or in the lower animals. Dr. Armand Ruffler was specially well qualified to speak on this subject, from his long and intimate acquaintance with the working of the

Pasteur Institute, and he had much pleasure in calling upon him to read his paper.

The paper read was—

RABIES AND ITS PREVENTIVE TREATMENT.

By Armand Ruffer, M.A., M.D.

During the last four years—that is, since the publication of Pasteur's researches on the antirabic treatment as applied to man—many and important papers have appeared on the subject which is to occupy us to-night. The critical minds of medical men, always anxious to test the truth of any so-called discovery, seized on M. Pasteur's statements and submitted them to the rigid test of experimental criticism. The political press, likewise wishing to give its readers the latest news, published more or less accurate information concerning the mode of treatment followed at the Pasteur Institute, and also reproduced letters from a large number of persons who wished to air their opinions about rabies.

In this country, during the course of the year 1889, much has been spoken and written about the disease. I need only refer to Sir Henry Roscoe's Bill for the compulsory muzzling of dogs, to the speeches made on July 1st at the Mansion-house by many eminent men, to Mr. Kerslake's paper before the Balloon Society, and to M. Pasteur's contribution to the *New Review*. I cannot be expected therefore, to raise any very new points, and indeed I would not have ventured to speak here to-night if I had not been requested to do so by your Secretary, at the suggestion of some of my scientific friends. He asked me to do so simply because he knew I had had many opportunities to see rabies in man and animals, and to watch during several months the immediate and remote effects of the antirabic treatment.

In this paper I shall not attempt to give a résumé of all that has been written on rabies, for the literature on that subject is so large that the mere enumeration of the remedies which have been used against it would occupy more than the time at our disposal.

I must limit myself to giving an account of the nature of the disease. I intend to indicate the means at our disposal to eradicate it, and lastly to show how its occurrence may be prevented in human beings even if they have been bitten by rabid animals.

Rabies is a specific infectious disease, and like all other specific diseases, its first origin is unknown. We do not know how and why the first animal or man who presented the signs of rabies was afflicted with the disease, just as we do not know how small-pox or measles originated. What we *do* know is that nowadays it never occurs spontaneously, that whenever and wherever human beings or animals show the typical symptoms of the disease, the origin of the affliction may be traced to the bite of a rabid animal or to the accidental introduction of rabic virus through a scratch or cut.

If that is so, it necessarily follows that if it was possible to find a place—an island, for instance—where rabies has been efficiently stamped out, no cases ought to occur in that place unless the disease be imported by a rabid animal. That is indeed the case. It is not to be met with in islands, whatever their size may be, in which it has once been efficiently stamped out, and in which dogs are brought on shore after having been kept in quarantine for a period of time of several months. And that is the case whether the island be situated in tropical, temperate, or cold climates. But whenever and wherever (in a country in which there is but a single case of rabies) dogs are allowed to roam at large—especially unmuzzled—or where many wild animals, such as wolves, are afflicted with the disease, cases of rabies must occur in men also.

Climate seems to have no, or very little, influence on its production. It has appeared among dogs in an Arctic expedition, it is common in our countries, it is found in the East, on the coasts of Africa, in Brazil, in India, in China, and broke out with frightful malignancy when accidentally introduced at the Cape. Statements that it does not occur in the East of Europe have been frequently made, and it seemed strange that in a place like Constantinople, where dogs roam unmuzzled about the streets, the disease should be unknown. Unfortunately it is totally untrue, and so numerous are the cases of rabies occurring among human beings in that town, that His Majesty the Sultan, in 1887, endowed an institute for the treatment of men bitten by rabid animals.

Heat and thirst have been supposed by many to have some influence on the production of the malady. That heat has little to do with it is shown by the fact that rabies occurs in cold as well as in hot climates. In temperate climates, cases occurring among dogs appear to be as common, if not more so, in the winter than in the summer. I have been able to get confirmatory evidence of this fact in the following way. At the Pasteur Institute in Paris, patients come to be treated from France, England, Belgium, and Portugal, after having been bitten by rabid animals or animals supposed to be rabid. I have, from the accurate records kept at the Institute, prepared a diagram showing the number of human beings who presented themselves for treatment during the years 1887 and 1888. In order to ensure greater accuracy, I have carefully excluded all patients bitten by animals in which the disease had not been proved to be present, either by the test of inoculation or by a veterinary surgeon's certificate. If you look at the diagram on the wall you will see that 56 per cent. of all cases occur from December 1st to June 1st, and 44 per cent. from June 1st to December 1st. Notice also that the highest number in both years came to the Institute in February, and the lowest in November, and that comparatively few patients were bitten in June, July, and August. I think we may conclude from these diagrams that, in late years, the chances of being bitten by a rabid animal are certainly as great in the winter as in the summer.

Cruelty as a cause of rabies may also be excluded. That ill-treatment may cause even a good tempered animal to become vicious, or that a dog after being goaded to fury will turn on its master and bite him is true enough; but that animal is no more rabid than is the negro slave who brains his master with a club. There is not a particle of evidence to show that ill-treatment will produce rabies. Cruelty to a dog will no more give rise to the disease than ill-treatment will produce small-pox in a human being.

The chief propagator of the disease, in this country at least, is the dog. This animal, when the first symptoms make their appearance, does not always present the symptoms which to most people are characteristic of rabies. It usually is not afraid of water, and instead of showing signs of fury, the first symptom is at times an increase in the affectionate sentiments of the animal. The dog does not bite its master at first, but will often lick its owner's hand or face, or even other dogs it comes across. Even then, however, the saliva of the animal already contains the virus, and I have seen a man die of rabies after having been licked on a sore place on the hand by his own dog. Later on it often becomes sullen and morose, with a very characteristic bark biting other dogs it come across; frequently runs away, snapping at animals or men as it meets them, until exhausted it dies in a ditch or field, sixty or seventy miles from home sometimes. If that be the ordinary or popular form, the other variety, or dumb-rabies, characterised by the symptoms of paralysis, is not less common and just as dangerous; for, many are not on their guard against it, and may unwittingly expose themselves to contagion. The virus is the same, but gives rise to different symptoms. This is proved by the fact that an animal with furious rabies biting another of the same species, may produce dumb rabies in its brother.

In Russia and other countries where wolves are numerous, rabies is often propagated by these animals also. A rabid wolf during the furious stage of the disease is a most terrible animal to meet. One of these brutes, when suffering from rabies, occasionally gets into a village during the day, and bites every animal or human being it comes across, attacking sometimes as many as 60 or 70 persons in one day. The bites are extremely severe, for, unlike the dog, which often gives a snap only and then passes on, the wolf sticks to its victim, bites and worries it so relentlessly that it is not rare for these poor people to die from their wounds on the same or next day.

Rabies is occasionally met with in foxes, horses, sheep, pigs, and cattle which have been bitten by other rabid animals, but the cases in which the disease has been communicated to human beings by such animals are extremely rare. Lately, there have been two epidemics of rabies among deer, one at Richmond and the other at Ickworth in the park of the Marquis of Bristol. During the latter epidemic, my friend, Mr. Adami, accidentally inoculated himself with the virus, but as I see him here to-night, I will not say anything more about it, for I hope that he will presently give us his experiences of the disease.

The domestic cat has been known to communicate rabies to man. A rabid cat, however, is not nearly so dangerous as a dog afflicted with the same disease, for the former hides away in some dark place, and only throws itself on animals and human beings when these come too near or disturb it. The dog, on the other hand, runs through large tracts of country, and thus becomes the common carrier of the dread virus.

The signs of the disease in man have been accurately described by many competent medical men, but the popular notion as to the symptoms are very vague and erroneous in many points. The popular description of a human being suffering from rabies—or hydrophobia, as it is sometimes called—is that of a violent madman, barking, howling, and trying to bite. As a matter of fact, in many cases the patient is perfectly calm and conscious, and the attacks of excitement are rare. The public does not recognise the fact that the patient foams at the mouth merely because he is unable to swallow his saliva. The voice becomes hoarse, and changed in character on account of the dryness and spasms of the throat, so that the cries of such a patient sometimes resemble, in the very vaguest manner, the barking of a dog. Further, a patient thus afflicted will occasionally bite the attendants during a paroxysmal attack of fury, just as any other patient suffering from ordinary acute mania may do so, but, in the large majority of cases, he does not try to injure those near him, and hardly ever tries to bite. The patients sometimes have no attacks of excitement whatsoever, and the affectionate sentiments are then often greatly exaggerated; the patient crying, takes leave of friends, bemoans his fate and lastly dies exhausted. In fact, one of the most painful sights it was ever my misfortune to witness, was that of a young girl of 18, in the last stage of rabies, taking a final farewell from her friends.

Popular imagination had been struck by one symptom, namely, the fear of water, or hydrophobia. Many had noticed that a rabid dog is often totally unable to drink, and that the face of a rabid human patient betrays all the signs of fear and horror whenever he sees water, or even hears the sound of falling liquids From times immemorial the public—physicians even—have given to diseases the name of one of their most striking symptoms, and we need not wonder then that the words "rabies" and "hydrophobia" have become synonymous. This is, nevertheless, based on error, for, although a rabid dog is not able to drink, it does not fear water as a rule. The human being likewise, shudders at the sight of fluid, because it gives rise to most painful spasms of the throat, though in a few cases the patient has no fear of water at all, and is able to drink right through the course of the disease. Lastly, the form of rabies in which paralysis is the chief symptom, unknown to the general public, was but little studied by physicians.

This mere sketch of the symptoms will certainly suffice to show you that this malady is a most interesting and terrible one. Another reason which adds to the fear with which the public regard this affliction, is the fact that a human being, bitten by a rabid animal, remains for weeks, months, and even years in a state of anxiety and suspense concerning his fate. The majority of persons, namely 90 per cent. of those who do perish after the introduction of the poison, die within four months, and more than 99 per cent. within the year. The cases dying more than one year after the bite are extremely rare, as the diagram on the wall shows. These unfortunate patients, however, know that if once the first symptoms of the disease make their appearance, they are doomed to a certain death, and although cases of recovery after the appearance of the first symptoms have been described, I confess that I have been unable to satisfy myself that a human being who has once shown some definite symptoms has ever got well. Cases of recovery in dogs undoubtedly do occur.

And yet an account of the remedies against rabies, which have been lauded by their discoverers, would fill the pages of a good-sized volume. Celsus, living in Caligula's time, stated that the best way of curing a patient afflicted with rabies was to throw him into a swimming bath. This treatment was extolled by almost every author through nearly eighteen centuries, until Morgagni showed how useless it really was. Others advised the bitten man to eat the liver or brain of the animal which inflicted the wound. During the Middle Ages, and even now, the chapel of St. Hubert, in the Ardennes, is a place of pilgrimage to which people bitten by rabid animals still proceed. The patients at St. Hubert (according to the "Revue Encyclopédique") are told that they are not to change their linen, that they must always eat in the same plate, drink no white wine, not look into a mirror, always gaze straight before them when taking their walks abroad, and not wash themselves. This treatment lasts forty days. In Italy, the keys of a church near Rovigo when touched are also supposed to prevent the occurrence of rabies in patients bitten by rabid animals, and the same supposed curative power is also attributed to the keys of St. Guilterie, St. Roch, and St. Pierre de Bruges.

The treatment by Turkish baths, reintroduced by Bouisson, is by no means new, for it was described by Celsus, and also by Dioscorides. I need not tell you that this mode of treatment is absolutely useless, for my friend Mr. Horsley, in 1888, showed that the notion on which it is based is utterly fall lacious, and further that animals so treated, after having been inoculated with rabies, die even quicker than others in which the disease is allowed to run its own independent course.

Of the number of drugs which have been tried to prevent the occurrence of rabies, or to cure it when the symptoms have made their appearance, I need not give an account. Shortly stated, there is no drug which cures the disease, though much may be done by narcotics, such as chloroform, chloral, and morphia, to alleviate pain, and render death more easy.

Cauterisation or sucking of the wound have been said to prevent the occurrence of rabies in patients so treated. I am quite at a loss how to form an opinion on that point, for the reason that I have been unable to find any reliable data on which I could base a belief in their value, the statistics given by various authors being quite unreliable. Judging from personal experience, I feel inclined to doubt the value of cauterisation, for among the human beings I have seen die of rabies, were two who had been carefully cauterised by medical men very soon after the wound had been inflicted, and of three persons I know, bitten by the same rabid dog, the only one who died was the one who had been cauterised immediately after the bite. Such then being, roughly speaking, our knowledge of the chief phenomena of this affliction, let us see what can be done to put a stop to the spread of the disease and to prevent its occurrence, when a human being has been bitten by a rabid animal.

When discussing the spread of rabies amongst animals, I showed you that the dog, in this country at least, was the chief propagator of the disease, and that if it were possible to destroy the virus now living in some of the dogs of this country, the disease would be practically stamped out of England, as it never occurs spontaneously. The virus, unlike that of other diseases, has the peculiarity that it will not thrive outside the living body. Every physician knows that the virus of scarlet fever, for instance, will hang about the clothes or the room of a scarlatinal patient for days, weeks, months, or even years, unless these objects or localities be thoroughly disinfected. Again, an animal dying of anthrax, if simply buried in a field, does not, for that reason, become harmless. The soil, the water, every thing touching the dead carcase of that animal becomes contaminated, and months, years afterwards, a bullock or sheep grazing over the grave of its fellow, may become infected by the anthrax virus brought to the surface by the labourer's spade, through the action of earth worms or through some other means. It is not so with rabies, and it is lucky that this virus dies so very easily, for if it had the same resisting power as that of anthrax, it would be the most frightful scourge to humanity. On the contrary, it does not retain its vitality for any length of time after the animal carrying it is dead, but a few days, or one or two months at most, after the death of the animal, it perishes also. Similarly again, the virus contained in the saliva dribbling from the mouth of a rabid dog, or present in the dejections of the animal, dies in a very short time—as soon as sunlight and dryness have acted upon it.

What, then, are the measures which must be adopted to stamp out the virus amongst the dogs alive at this present moment? I may assume that you are as strongly opposed as I am to all such measures as wholesale destruction of dogs by poisoned meat, or as filing their teeth, measures which have been proposed in this century even. I think there are only two regulations which are of any use whatsoever.

1. The registration of all dogs, and the wearing of a collar by each dog, with the name of the animal's owner engraved on it; all dogs not wearing such a collar to be at once destroyed.

2. The destruction of all stray dogs, and the muzzling of all others, together with quarantine for all imported dogs.

Of the two, the first must be considered, if applied alone, as inefficient, because it will not prevent dogs in the first stage of rabies from biting other dogs. Remember that, before the actual typical symptoms of rabies have made their appearance, when the unfortunate animal's condition is often betrayed only by an exaggeration in its affectionate sentiments, a dog is already dangerous and its bite will produce rabies. If that animal be allowed to go about unmuzzled in the streets, it may infect others before the disease is diagnosed. Further, in countries such as Belgium, in which it has been tried, registration of dogs has proved powerless to arrest the disease.

The muzzle certainly prevents contamination during the early stages of the disease at least, and, in some cases, even when the more prominent symptoms have made their appearance. It has been said that a rabid dog always gets off, and that accordingly the muzzle would not be of any use, because it would run away without it. That to some extent is true, but it is not always so. To give you an example—and Mr. Millais will contradict me if I exaggerate, for he also knows the facts of the case—I will mention the case of a dog suffering from all the acute symptoms of rabies, which was brought unmuzzled by its mistress in the train all the way from Bangor, in Wales, to London, was led through the streets of London from the station to Wandsworth, where it finally died. The owner, a lady, stated that during its progress it did not bite anybody, but as she confessed that it rushed at every living being it came across, and bit her in the hand, I think we are justified in doubting the truth of her statement. Now that dog, under an efficient Muzzling Act, could not have done any mischief because it must have been brought muzzled through the town. But, in his masterly paper read before the Balloon Society, my friend Mr. Kerslake has so well stated every argument which can be brought forward in favour of muzzling, that I must refer you to his paper for further information. He has conclusively shown that whenever and wherever muzzling has been efficiently carried out, the deaths from rabies have become fewer, or are even totally absent. In England the circumstances would be very favourable, because, the country being surrounded by water, no stray dogs can come in from parts where muzzling is not enforced, and because there are no wolves and hardly any other wild animals to propagate the disease *de novo* if once efficiently stamped out in the canine species. Muzzling, to be efficient, ought to be enforced on all dogs throughout the country, though it must not be forgotten that even local muzzling will do something to stamp out the disease. In Paris a muzzling order was efficiently carried out during three months, and the number of people bitten came down from 67 to 19 per month at the end of that period.

I said that destruction of all stray dogs must be enforced at the same time. The ownerless dogs wandering about the streets must, of course, be more frequently exposed to bites from rabid animals. In many countries they are seized by the police and brought to some place where, after being kept for some time, they are destroyed, or, if valuable, sold. Now, every dog which has been roaming about the streets may have been bitten by a rabid animal, and, if not to be destroyed, ought to be kept under observation for a period of time long enough to exclude all chances of rabies making its appearance, should it, whilst at large, have been inoculated with rabies. In my opinion therefore, every dog unclaimed by its owner ought to be destroyed, unless it be completely isolated from other dogs for a period of least six months before being sold.

At present, however, there is still a chance of some of us here to-night being bitten by rabid animals, and if I mistake not there are at least two persons in the room who have been so bitten. I think what most of you would like to ask me is this—"Suppose you had been bitten by a dog, and the veterinary surgeon had told you that the animal was rabid, or suppose you had been bitten by a stray dog you thought was rabid, what would you do?" That, I think, is the practical—the patient's—point of view.

To answer that question it is necessary to know what the mortality really amounts to among persons who have been bitten by rabid animals and who have not undergone any preventive treatment.

In the case of persons bitten by rabid domestic animals, the mortality has been variously estimated. Faber has tabulated the cases of 145 people bitten by rabid animals in the kingdom of Wurtemberg, and he found that the mortality amounted to 19 per cent. At the General Hospital in Vienna, in 1860, it was found that of 115 persons bitten by rabid animals 25 died (mortality 21·73 per cent.). Leblanc states that of 32 people bitten by dogs undoubtedly rabid, five died (mortality 15·82 per cent.). During the year 1887 forty-four people bitten in Paris by rabid animals declined to undergo M. Pasteur's treatment, and seven of them died (mortality 15·9 per cent.). Other statistics show a mortality varying between 20 and 50 per cent., but these numbers are probably too high, because they are derived from official reports, the officers of the State being more likely to know of the fatal cases than of those which ended in recovery, and I shall, for the sake of argument, assume the mortality to be 15 per cent., although I believe this number to be somewhat too low.

The statistics of the Comité d'Hygiene from 1862 to 1872 show that of people bitten on the face 88 per cent. died (50 cases), on the hands 67·25 per cent. died (113 cases), on the upper limbs 30 per cent. (40 cases), on the lower limbs 21·21 per cent. died (33 cases), on the trunk 31·81 per cent. died (22 cases), on the face and hands two men died out of eight persons bitten.

In the case of wolf bites, the statistics of Renauld, Vallet, du Mesnil Bombarda, Gamaleïa, and others, comprising together 1,296 cases of wolf bites, show a mortality of 60 to 64 per cent. Thus, for instance, one wolf at Ewanguliezenvic, in Russia, bit 35 men and 23 women. The wounds were cauterised with caustic potash, but, nevertheless, 24 men and 15 women died (mortality 67·24 per cent.) within six months.

I shall again assume the lowest figure to be correct, and the mortality from wolf bites to be 60 per cent.

Let us now see the results which M. Pasteur has obtained by his treatment, but first let me say a few words concerning the mode of production of the virus which is used for inoculation, as I find that some errors on the subject have, unwittingly no doubt, found their way into the daily papers.

When in 1880 M. Pasteur began to study rabies, he had already published several other discoveries concerning preventive inoculations in other diseases. He had been able to inoculate against the bacillus of anthrax, against cholera of fowl and against swine - fever, every one of these diseases being due to micro-organisms. It was easy to obtain the vaccinating matter or modified virus for these diseases, because the micro-organisms which are the cause of the disease can be grown outside the animal's body, body, in gelatine or beef-broth, just as potatoes may be grown in a field; and may then be bottled up, just as claret may be bottled up in a flask. He was convinced that rabies was due to a like micro-organism, but all attempts to see or to cultivate it had proved fruitless. He was obliged therefore, in order to get a supply of virus at all, to inoculate animals, just as public vaccinators inoculate calves to obtain the vaccine-matter against small-pox. After many attempts, however, he found that if the virus of rabies be inoculated under the membrane covering the brain of a rabbit, the animal always dies of rabies, and since that time rabbits only, and not dogs, as has been inaccurately stated, are always used for the production of the necessary virus.

Let me tell you how the operation is performed. The rabbit is first chloroformed. Then, a small incision, about half inch long, is made on the top of the head; a disc of bone, the size of half a threepenny bit, is removed, and two drops of the virus injected through a very fine needle under the membrane covering the brain. The wound is sutured and carefully washed, the whole operation lasting less than two minutes. The animal is placed back into its cage, and after the effects of the chloroform have passed off, in a space of time not exceeding ten minutes, one may see it feeding and hopping about as if nothing was the matter. Six to seven days afterwards the first signs of the disease appear. This is marked by paralysis, which gradually increases until the animal dies. It suffers no inconvenience from the wound, as, owing to antiseptic precautions being taken, this never inflames. The whole course of the disease in the rabbit is a remarkably painless one, the animal showing no signs of pain. I may be allowed to state that I have frequently taken not only medical men, but other friends, clergymen, and even ladies, to see these animals, and that all of them have been convinced that there is not the slightest cruelty in the whole process.

After the death of the animal, the spinal cord is taken out, and the virus it contains gradually weakened by drying, until ready for injection. The inoculations in man are made into the skin of the abdomen, but as I see one here to-night who has undergone the whole process, I will let him give you an account of the immediate and remote effect of the treatment.

In this month's *New Review* will be found an account of how M. Pasteur was led to apply this method to man, and I will therefore pass on at once to the practical results of M. Pasteur's inoculations.

During the period extending from November, 1885, to January, 1886, 2,164 human beings, bitten by animals proved to be rabid, were inoculated at M. Pasteur's Institute in Paris. Of these, 32 died (mortality 1·47 per cent.) On the other hand, 518 persons bitten by animals strongly suspected of rabies were submitted to the same treatment. Of these, 3 died (mortality 0·58 per cent.).

Notice that in the statistics are reckoned those even who died immediately after treatment, and before, in many cases at least, it could have had any beneficial effect.

The two following tables will show you better than any words of mine, the result of M. Pasteur's treatment during the years 1887 and 1888:—

Table I.—January 1st to December 31st, 1887.

	A.	B.	C.
Number of persons inoculated	1,778	1,501	277
Mortality, per cent., *a*	1·34	1·52	0·78
„ „ *b*	12·1	1·26	*nil*

Table II.—January 1st to December 31st, 1888.

	A.	B.	C.
Number of persons inoculated	1,626	1,371	255
Mortality, per cent., *a*	1·16	1·31	0·39
„ „ *b*	0·79	0·94	*nil*

EXPLANATION.—Column A in each Table includes all the cases inoculated at the Pasteur Institute during the year. Column B includes only patients bitten by animals proved to be rabid at the time they inflicted the wound. (This corresponds to columns A and B in M. Pasteur's own Table.) Column C gives the number of patients bitten by animals which, though presumably rabid, could not be proved to have been so.

Mortality *a*.—Total mortality, including patients dying during the progress of treatment. Mortality *b*.—Mortality after those dying during treatment have been excluded. *The lowest mortality in people bitten by rabid animals and not inoculated amounts to 15 per cent. at least.*

As animals proved to be rabid, only those are counted in which the disease has been proved to be present by the test of inoculation, or by certificate from veterinary surgeons who have seen the animal alive, or performed a *post-mortem* on it.

You will notice that the mortality has been steadily decreasing each year as the methods of inoculation have improved, and I may tell you that this year the total mortality will probably not amount to ·50 per cent.

If we remember that among these cases there are no less than 280 cases of face-bites, and that the mortality among people bitten in the face and not inoculated amounted to 80 per cent., and if we also bear in mind that the lowest mortality among non-inoculated persons bitten in any part of the body amounts to 15 per cent, at least, we can form an opinion of the value of M. Pasteur's treatment.

But we medical men belong to a sceptical corporation, and for the following reason. When we read in one of our medical papers of a new mode of treatment or drug, we are well aware that at first this mode of treatment or remedy is always extremely successful. It cures everything (in the hands of its promoters at least), from polypus of the nose to gout in the big toe. Then, as the drug gets into the hands of other men, it is found that it is not the panacea which it was at first supposed to be, and it is but rarely that a new mode of treatment or a new remedy stands the test of time and criticism at the hands of independent observers.

Let us see now whether this applies to rabies also, for it would be an error to think that M. Pasteur is the only one who has applied this treatment. The experiments on which it is based have been repeated and proved to be correct by Mr. Horsley, and published in the Report of the Royal Commission appointed at Sir Henry Roscoe's instigation. Antirabic institutes have been established in many parts, so that at the present time there are more than twenty of these establishments scattered all over the world. There are no less than seven of them in Russia alone.

When, in the month of August last, I was asked to read a paper before the British Medical Association on the same subject, I took care to write and obtain information as to the results obtained in these institutes. I give you here the various data as I was able to obtain them from official letters, without withholding one syllable of what might tell against M. Pasteur's treatment.

In the last six months of the year 1886, Bujwid inoculated 104 persons bitten by animals proved to be rabid, or which were most probably so. He lost one patient. He then tried a weaker treatment on 193 patients; eight of these died, amongst them being all those who had been bitten in the face. M. Bujwid then determined to give the intensive treatment a trial. He inoculated 370 persons bitten by animals undoubtedly rabid; four had been bitten in the face by wolves, thirty by rabid dogs in the face. All these 370 people are alive now, more than one year after the last inoculation. M. Bujwid, in a private letter to me, dated July 29th, 1889, tells me that he has inoculated 146 patients this year, of whom one has died. He also tells me that in his part of the country, and during his time of office at Warsaw, thirty-one persons who were not inoculated died of rabies, although, as he remarks, very few refuse to be inoculated nowadays after having been bitten.

At St. Petersburg 484 patients were inoculated from July 13th, 1886, to September 13th, 1888. The mortality is somewhat higher, being 2·68 per cent.

At Odessa, Dr. Gamaleïa inoculated 324 persons in 1886 by the simple method, mortality 3·39 per cent. In 1887 he inoculated 345 persons by the intensive method, mortality 0·58 per cent.; whilst in 1888 the mortality amongst 364 persons amounted to 0·64 per cent. Dr. Bardach, the present director of the "Institut Antirabique" of Odessa, has been kind enough to send me the following information:—Twenty-six persons were inoculated after being bitten in the face by dogs proved to be rabid; of these one child, seven years old, died. It is only fair to state that this unfortunate child arrived at Odessa fourteen days after the bite, and that it died on the nineteenth day after the wound was inflicted, that is, on the fifth day of treatment, before the latter could have produced any effect. All the patients who had recovered had been most fearfully bitten, one of them having had the face almost torn off by eight dreadful bites, and bitten eleven times in the hand besides; another showing thirteen deep wounds inflicted in the face by a rabid wolf. Of the 333 persons inoculated by Dr. Bardach only two died (mortality 0·63 per cent.) Among the successful cases was one with thirty deep wounds, the results of bites from a wolf proved to be rabid. Among the 333 above mentioned were seven men who had never been bitten, but who insisted on being inoculated as a preventive measure (mortality *nil*).

At Moscow Dr. Gwozdreff inoculated 107 persons in 1886 by the simple method (mortality 8·40 per cent.). In 1887, with the intensive treatment, the mortality was 1·27 per cent. amongst 280 inoculated persons. Dr. Jules Goldenach (Chef de l'Hopital Empereur Alexander III., Moscow), in a private letter, informs me that at Moscow, during the year 1888, 431 persons were inoculated according to M. Pasteur's method; 328 had been bitten by rabid domestic animals (mortality 1·82 per cent.), whilst of 70 bitten by wolves 10 died (mortality 14·28 per cent.). Three of the deaths occurred in patients bitten in the face and head. One of them died only ten days after the treatment was finished, the other two dying during the progress of treatment—that is, before the preventive inoculations could have had any effect. Seven of the 11 deaths following wolf bites occurred in persons bitten in the face and head, whilst eight of them took place either during the progress of treatment or within 14 days after the last preventive inoculations—that is, 15, 19, 21, 24, 27, 28, 33, 44 days after the bite. Of the two others, one died 45 and the other 51 days after being bitten.

These Russian statistics are extremely interesting, for a great many of these patients were bitten by rabid wolves, and we know that after bites from these animals the mortality in non-inoculated persons varies between 60 and 64 per cent. Gamaleïa, in 1888, collected 119 cases of persons bitten by wolves and inoculated according to M. Pasteur's methods; of these, eight died (mortality 6·72 per cent.). M. Pasteur's treatment, therefore, saved 63 of these patients from a painful death, as the mortality after wolf-bites in non-inoculated persons reaches 60 per cent.

In Italy, at Turin, Dr Guido Bordoni Uffreduzzi has inoculated 531 persons, 486 patients having been bitten by animals undoubtedly rabid. Of these ten died (mortality 1·88 per cent.). Of 43 persons bitten in the face and inoculated he only lost one. At Milan, Dr. Baratieri has inoculated 335 persons up to November, 1888, and lost two.

Dr. Luigi di Blasi has kindly sent me the following account of his inoculations at Palermo. He has inoculated 343 persons since March, 1887, 68 being treated by the simple method (mortality 0.72 per cent.). 170 patients had been bitten by animals proved to be rabid. Of 21 patients bitten in the face one died, whilst of the 332 patients bitten in various parts of the body only three perished.

At Naples, Professor Cantani, assisted by Drs. di Vestea and Zagari, has inoculated 347 persons, of whom 296 had been bitten by animals proved to be rabid (mortality 1·72 per cent.). It is noteworthy that, during a period of seven months, Professor Cantani had to close his Antirabic Institute for want of funds, M. Pasteur's opponents being very powerful at Naples. During that period, however, nine persons died of rabies at Naples, and the Pasteur Institute had to be re-opened.

At Constantinople 34 persons have been inoculated, up to November, 1888, of whom not one has died.

At Havana, Dr. Tamayo has inoculated 170 persons (mortality 0·60 per cent.).

I have other facts, however, to bring forward, facts which have almost the value of a scientific experiment. A number of cases are to be found in the annals of the Antirabic Institutes, in which several persons having been bitten by the same animals, some have undergone M. Pasteur's treatment, and others, for various reasons, have not.

In the year 1887, 350 persons were bitten in Paris by rabid animals, 306 of them were inoculated by M. Pasteur, and three of them died =0·97 per cent.; 44 trusted to luck, and declined to be inoculated, and of these seven died—mortality, 15·9 per cent. These facts were elucidated by careful inquiries made by an independent medical man acting for the Prefect of Police, who is not in any way connected with the Pasteur Institute.

But there are other facts from other countries showing the same results. Only lately I have received a letter from Professor Babes, a well-known bacteriologist, who has given me the following particulars as to the results of the inoculations practised at the Antirabic Institute of Bucharest in Roumania. From the 1st of May to the 1st of August, 1889, 244 persons were inoculated at Bucharest, after having been bitten by rabid domestic animals. The mortality among these persons is absolutely *nil.* On the other hand, 39 persons bitten by the same rabid animals declined to undergo treatment, and four of these, at least, have been certified as having died from rabies.

Thirty-four persons were badly bitten by wolves on the hand and were inoculated, and of these three died from rabies. On the other hand, every one of the persons who refused to undergo treatment after having been bitten by the same wolves as those before-mentioned has died of rabies, as did 180 head of cattle bitten by the same animals.

Högyes has published the following facts:—During the period of time extending from the 1st of November, 1885, to the end of June, 1888, 532 human beings were officially registered in Hungary as having been bitten by rabid animals. Sixty-two of these persons were inoculated, and not a single one has died of rabies. On the other hand, of the 470 persons who were not inoculated, 44 at least have been certified as having died of rabies.

I think it will be difficult, even for the most sceptical of men, to deny that M. Pasteur's treatment is often successful.

Many have stated that people have died from Pasteur's treatment who had never been bitten by rabid animals at all. I have made careful inquiries on that point, and what I can say is this, that the cases which have been published as occurring in France are absolutely and utterly false. For those published in Russia I cannot answer definitely, but what I can say is that I was unable to find any facts bearing out the truth of these statements in any of the official documents, and that all of them are based on mere hearsay evidence and daily newspaper's reports.

M. Pasteur's assistants, the directors of the Antirabic Institutes, most of the servants in the laboratories, who must know, if anybody does, the *pros* and *cons* of the treatment, have most of them been inoculated, and no less than five of my personal friends have undergone the treatment. Do you believe these men would run the risk of being inoculated if they did not feel quite certain as to the result?

But you might say some of these patients have died from rabies, and who tells me that they did not die of the virus which M. Pasteur injected? In the first place, there is not a particle of evidence to show that such an event did really happen; but assume, for the sake of argument, that every one of these patients who died perished as the direct result of M. Pasteur's treatment. Even then, if I were bitten by a rabid animal I would go and be inoculated. For, let us compare M. Pasteur's treatment to a surgical operation. If any one of us was suffering from a tumour, and a well-known surgeon came to him and said: "I have operated on over 7,000 cases similar to yours, the operation is almost painless, and the mortality among my patients is one per cent.; but if you undergo no treatment your chances of death increase to sixteen per cent." Is there one of us here to-night who would not at once place himself under the surgeon's hands, and undergo that operation, when, by doing so his chances of life must increase from 84 to 99 per cent.

My answer to your question is therefore this, "If ever I am bitten by a rabid dog, or an animal I supposed was rabid, my intention is to take the first train to Paris and be inoculated."

This paper has lasted much longer than I wished it to last, but my excuse is that I thought it would be well to give you a *resumé* of the most important facts on which you can base an opinion. I will trespass just for a few seconds more, and perhaps you will allow me to give in one sentence my opinion—for I do not presume to give advice—as to what should be done to stamp out the disease. Muzzle all dogs, destroy all stray dogs, have a quarantine of six months for all imported dogs, and the disease will be stamped out of this country for ever. Meanwhile, before this has been effected, if you are bitten by a rabid animal do not trust to luck or cauterisation, but go and be inoculated at once.

DISCUSSION.

The SECRETARY read the following letter he had received from Sir Henry Roscoe, M.P., F.R.S.:—"I am sorry that I cannot be present on Wednesday next to hear Dr. Ruffer's paper, as I am engaged in Manchester on that day. The subject of Pasteur's method for the cure of hydrophobia is one of the most interesting applications of modern scientific research to the benefit of humanity, but not less important is the mode by which this disease may be prevented by stamping out its cause—rabies. The Society of Arts is doing good service by bringing this question forward, and I trust that the interest now taken by the public in the matter may enable us to pass a general muzzling Bill during the next session of Parliament, by which this most desirable end will be attained."

The CHAIRMAN said he would first ask Dr. Adami, who had undergone the treatment, to give an account of his experience.

Dr. J. G. ADAMI (Christ's College, Cambridge) said he appeared there that evening as the "awful example." During the present year there had been a remarkable epidemic of rabies amongst the deer in the Marquis of Bristol's park at Ickworth, and whilst engaged in investigating the malady, in making a *post-mortem* examination, he unfortunately cut himself. At the time, not knowing what the disease was, he thought very little of it, and simply cauterised the wound, but a few days later, when he obtained convincing evidence that the deer were dying rapidly of rabies, and when he also found that the knife with which he had cut himself had been used to dissect the brain and spinal cord of the deer, he became apprehensive, and rushed off to Paris. He found the Pasteur Institute a large, handsome, and cheerful building in the suburbs, containing a large library and many other rooms besides those used in the antirabic treatment. The course was this:—The patient was first shown into a large waiting-room, very well appointed, and much more cheerful than any out-patients' room he had seen in England. From this room he passed into a smaller one like an office, round which were placed the *dossiers* of previous patients, and on the table was a large book in which all particulars were entered, two pages being allotted to each patient, giving all the details both of the bite, the animal, its condition, &c., and the treatment. Not having looked up the subject previously, he was in some doubt before going to Paris as to the value of M. Pasteur's statistics, but immediately on his arrival every information was afforded him; he had free access to the laboratory, and to all the books, and after a careful inspection he came to the conclusion that every care was taken that nothing was placed in the statistics but what was absolutely correct, and that everything was recorded, whether in favour of the treatment or against it. He need not describe the preparation of the virus, but might say that each day on entering the operating room you found a number of persons of various ages and nationalities, and on one occasion he found himself between a Jesuit curé and an Arab sheik; and there were adults and almost babies in arms, and all formed *queue* in the regular French fashion. The operation was performed on one patient after another with a small hypodermic syringe, the virus used at first being very weak and afterwards gradually increased in strength, about 30 minims being injected into the walls of the abdomen. To some few persons this operation seemed very painful, and one patient spoke of it as a fiery ordeal, but, as a rule, there was no pain worth mentioning, and several English children who were there, on the recommendation of himself and a friend who was with him, never showed either fear or pain, and many of the French children tried to follow their example. Five minutes afterwards there was no discomfort whatever from the puncture. Whilst there he saw every detail, and could confirm what Dr. Ruffer had said about the marvellous precision which governed every step. There were only two slight objections, perhaps, from an English point of view; one the semi-public character of the proceedings, and the other that there was practically no one there that could speak English sufficiently well to be of much use to an uneducated person. Both these objections would be removed if a similar institution were established in England. Shortly after the completion of the treatment, he experienced some rather anomalous symptoms, but even now he could not say whether they were subjective merely, or were of the nature of rabies, probably the former. If they were, he was saved an immense deal of suffering and anxiety from the security he felt, and if they were the latter, he was still more fortunate in having escaped so deadly a disease.

Prof. RAY LANKESTER, F.R.S., expressed his great satisfaction with the paper, which was a most able exposition of the whole case, and contained the most complete statistics bearing on the results of Pasteur's treatment. He could personally confirm the account given of the great completeness of the institution, and of the great care devoted to the preparation of the virus used in the treatment. He should be glad if the meeting could in some way express an opinion with regard to the two questions which had been raised as to muzzling, and the general feeling as to this method of prevention. It was desirable, in a country surrounded by the sea, to get rid altogether of a terrible disease like hydrophobia, and there was no reason why they should not. It was simply their own folly in assisting in nourishing it in their midst. They had only to muzzle all dogs, and impose a sufficient quarantine, to get rid of it entirely. There was no reason to believe that at the present time this disease had ever appeared *de novo*. It was probably of a prehistoric origin—handed on through various carnivorous animals, and from time to time affecting the dogs of civilised races through the attacks of wolves. In this island, there was no reason why it should exist, any more than wolves, which were got rid of in the reign of Edward III. It was not sufficient that dogs were muzzled in great towns, because after a time, when the immediate cause of disease was got rid of, London was again effected by the inroads of unmuzzled dogs from the wild country. The system ought to be universal, and public authorities ought to understand that this was a serious thing which should be carried out. Until within the last year or so it had not been understood by those having the reins of government that the muzzling of dogs would be effective, but there was no doubt about it now. As to Pasteur's treatment, he thought even the most sceptical must be convinced by its effects. During the first year the results were promising, but it was quite justifiable for anyone to withhold their judgment for a time. But there had now been four years' experience, and every year far better results had been obtained. The system had been tried, not only by Pasteur himself, but by others in various parts of Europe, and the results entirely confirmed those obtained by Pasteur himself, so that there could be no doubt of the great debt of gratitude which the whole civilised world owed to M. Pasteur.

Mr. WILLIAM HAUGHTON said that M. Pasteur's labours required no apology, and his researches in hydrophobia were better known than others, because this disease—although exceedingly rare—was surrounded in people's imagination with a halo of horror which did not attach to any other disease. Practically, however, it was so rare that they need not trouble about it. M. Pasteur's discoveries in this direction were but another link in the magnificent chain which enabled them to battle with every disease and to put surgery on a sure footing. With regard to stamping out hydrophobia by muzzling, however, if he believed it was effective he would advocate it, but he had satisfied himself that it was ineffective and could not attain the end desired. It was not a question of propagation, but stamping out, and it was an admitted fact that rabid dogs invariably escaped muzzling, and it therefore followed that the muzzle was put on the harmless dogs, and those which communicated contagion escaped. No one had ever yet seen a rabid dog at large with a muzzle on, nor had any been killed by the police in the streets. He quite admitted that what was miscalled muzzling had in many instances done a great deal of good. In 1885–6 there was an undoubted diminution of rabies, but that was because about 66,000 stray dogs were destroyed. The muzzling then in force was described even by its advocates as a farce, and yet they ascribed the decrease of rabies in those years, not to the destruction of the stray dogs, but to the muzzle. He would not go into lengthy statistics as there was no time, but he wished to protest against a proposition which he looked upon as mischievous and entirely useless.

Dr. G. FLEMING said he had the honour some ten years since of reading a paper on the contagious diseases of animals, and the means of suppressing them, and since that time one fell malady, the foot and mouth disease, had been practically eradicated. He then referred to rabies as a malady which caused great loss, and few had any conception of the injury it inflicted on the animal creation. The loss of property was very great in the shape of cattle, sheep, horses, and dogs who were killed by it, and in France the loss amongst domestic animals had been estimated at £40,000. It was high time, therefore, that attention should be directed to its prevention. No one had a greater reverence for Pasteur than he had; he was a member of the committee to which the Chairman had referred, and was glad to find that the conclusions then arrived at had been amply supported by further experience, and it was very satisfactory to find that the value of Pasteur's work was being generally recognised. The chief causes of the continuance of this disease in England were sentiment and ignorance of the nature of the disease. When he published a work upon it, sixteen years ago, he was rather inclined to believe in the spontaneity of the malady, his information not being then so full as it became immediately afterwards, and he had cases under his own observation which he could not trace to any source of contagion. His doubts were shared by eminent veterinarians on the continent, notably by his deceased friend M. Bouley; but shortly afterwards he had reason to change his opinion, and he now firmly believed that the disease never arose spontaneously. The best evidence of that was that in the Island of Bourbon it had been stamped out for more than half a century, though in the Island of Mauritius it raged with great virulence from time to time, and was never entirely absent. It was nonsense to say that muzzling dogs would send them mad; you might as well say that wearing a high collar would give a man the cholera. Six or seven years ago he was consulted by the Agent-General for New South Wales as to the best means of preventing the introduction of the disease into the colony, and he advised a strict quarantine of six months. Probably it would have been safer to name a longer period, but so far the measure had been effective in preventing the introduction of rabies, and he did not know that any stronger evidence could be given of the non-spontaneity of the disease than that afforded by the Australian colonies. He maintained that the use of the muzzle was the chief repressive measure. Wherever the muzzle had been employed as it should be, rabies had been either very much diminished or altogether extinguished. The objections to it were frivolous in the extreme, and he could not see why dogs should be exempted from a slight restriction of that kind, when horses had to bear shoeing, and to submit to a bit and a bearing-rein. Anyone who had ever seen either a human being or an animal die of rabies would advocate this measure at once. A properly constructed muzzle was no more hardship to a dog than a bit was to a horse. It not only prevented the dog biting, but was an indication that he had an owner, and was cared for; it was said that the stray dogs did the mischief, but how could you tell which were stray dogs without some visible indication, and there was no better indication than the muzzle. But muzzling to be effective, must be universally applied, and for a certain period. A rabid dog would run fifty or sixty miles before he was exhausted, which showed the futility of applying the muzzling order within a limited radius. If universally applied, the disease would soon be extinguished. He knew of no malady which could be more easily stamped out, for it was only communicated by biting, and if you prevented animals from biting, you would put an end to it.

Dr. CHARLES DRYSDALE desired to endorse every word in the paper, and particularly the statement that by muzzling dogs rabies might be got rid of. Throughout Germany they had no Pasteur institute, because there was no rabies to treat. Dr. Ruffer, it would be noticed, had made no allusion to Sweden or Norway, because there they had no rabies; and two years ago Professor Virchow said he thoroughly agreed with Pasteur's splendid discovery, but it was not required in Germany, because there they muzzled the dogs. He was a thorough believer in Pasteur's experiments, having attended his clinique for the last four years, and was thoroughly convinced by the way in which he proved his case. He treated 40 dogs and inoculated them preventively; then he injected over the *dura mater* a certain portion of rabid virus, and the dogs remained perfectly free from disease. After that he gave in his adhesion at once, the experiment being as conclusive as Jenner's with regard to vaccination.

Mr. DREW, as an ordinary member of the public, said he had visited the Pasteur Institute, and could confirm all that had been said by Dr. Adami as to the great care taken in every detail, and especially in one respect, which that gentleman had not mentioned, viz., the dipping the needle into boiling oil and other antiseptic measures, which were taken to prevent any possibility of tubercular or cognate infection.

Prof. VICTOR HORSLEY, F.R.S., said he had been studying this subject for the last four or five years, and should like to say a word on preventive measures. Mr. Haughton said he would not quote statistics, and he was not surprised at it, for statistics would entirely demolish his case; they showed that muzzling, when properly carried out, utterly abolished the disease, whether stray dogs were slaughtered or not. The only thing to do was to muzzle all dogs, and insist on a quarantine, because if the disease were once stamped out they did not want to admit it again. He was satisfied from conversations he had had with large dog owners and breeders that it would be quite possible to have a system of quarantine, without interfering with the very large traffic which went on between this country and the Continent, in showing highly-trained dogs at different exhibitions. Many practical points had been elicited by the Society for the prevention of hydrophobia, and they were not to be turned aside by any difficulties which had arisen, or were likely to arise. In 1886 the Dog Owners' Protection Society published a statement saying there was no such thing as rabies, and gave currency to many absurd inventions intended to throw ridicule on the efforts of the police to stamp out the disease; but all such efforts were futile; they were determined to abolish hydrophobia, and that could only be done by universal muzzling.

Mr. HAUGHTON said he was not afraid of statistics; he relied upon them, but he was afraid of the clock, as it was getting late.

Mr. MARTIN WOOD said the discussion had been all one way on the central question involved, but the general public were very sceptical with regard to medical statistics, and these statistics of Pasteur's were certainly not universally accepted. He could not go into the question at length, but the figures certainly included a large number of persons who were frightened into supposing they had rabies, for there had been an epidemic of fright on the subject, and this would seriously derange the statistics. Would the chairman, as a medical man, accept the position that there was no possible cure for hydrophobia? No doubt many futile remedies had been suggested, but one had been mentioned recently with great circumstantiality, which he understood was a preparation of aloes, with which some remarkable cures were said to have been effected. Again, with regard to the Buisson treatment, he thought it required something more than Professor Horsley's dictum to show that it was absolutely useless. It seemed to him, as a layman, quite as likely a method for eradicating the virus as M. Pasteur's method of introducing another virus into the body. The origin of the disease was an interesting and obstruse question. If, as was said, it never arose spontaneously, it would involve that some mad dog came out of Noah's Ark. Professor Ray Lankester got out of the difficulty by attributing it to a prehistoric origin, but the statement that it could never arise spontaneously required further confirmation.

The CHAIRMAN said there was one point which struck him very much on visiting the Pasteur Institute. It might have been feared that the introduction of an emulsion made from the spinal cords of rabbits would do mischief by introducing putrid matter likely to produce *septicæmia* unless the most extreme care was taken, and this naturally struck one as a weak point in the system. But when he visited the institute, he was delighted to find that the most extraordinary antiseptic precautions were taken, and not only so, but the brainand spinal cord which were to be used, were first put for some days into a sterilised *bouillon*, to ascertain whether they had any microbes adhering to them, and only if they proved perfectly free were they used. But, as he was informed, practically they never had to throw one away. He believed the more anyone went into the subject with a knowledge of it, the more he would be convinced of the absolute trustworthiness of the statistics. It struck him as an admirable instance of Pasteur's open-mindedness, that though he had spent so many years in elaborating his preventive system, he at once said:—"In England you are most favourably situated for getting rid of the disease, in consequence of your insulated position; you may make my method absolutely superfluous. Germany had to muzzle in perpetuity, being surrounded by nations who did not muzzle; but in England it would only be necessary to have a certain period—not very long—of universal muzzling, and then a rigid quarantine afterwards." If this were the real truth, the Legislature ought to be impressed with that view, and the thing ought to be done as Sir Henry Roscoe said.

Dr. RUFFER, in reply to Mr. Martin Wood, said the objection was that one mad dog must have existed some time, and if the disease never arose spontaneously they must assume he came out of Noah's Ark. That was true enough, but then they must assume that every infectious disease came out of the Ark, and as there were few people in it they must have been pretty bad. With regard to the statistics, he had carefully excluded from column B all cases except those in which the animal inflicting the bite had been proved to be mad. In the third column there might be some cases of fright, and he knew of two cases in which it turned out that the dog was not mad. He had had cases in England in which people had come to him, and on inquiry had seen no reason to suppose they had been bitten by a mad dog, and he had then advised them to go home. All the cases were carefully investigated. He had heard of people being cured after showing the first symptoms of hydrophobia, and had read of such cases, but he had been unable to satisfy himself that a patient who had ever shown the first typical symptoms had ever got well. The Buisson treatment had been tried in several places, in Leeds for instance, where Dr. Eddison told him he had tried it once, but would never do so again, and that he had to take the patient out as quickly as he could. This method had been often tried, and had always proved, when applied by competent men, perfectly useless as far as he knew. In his opinion, if all dogs were muzzled, rabies would disappear. The really dangerous stage was before the dog showed any marked symptoms, and during that time, if he were muzzled, it might prevent many dogs being bitten. Whenever muzzling had been efficiently carried out, rabies had disappeared, and that was enough for practical purposes. He would give particulars of five cases which he had come across in the records of the Pasteur Institute:—

"1. Cabout, Henry, a butcher's boy, was bitten on April 22nd, 1888, but did not undergo the anti-rabic treatment, and died in September, 1888. The same dog bit another person, Louis Pavie by name. The latter was inoculated from April 24th to May 11th, and is now in perfect health.

"2. M. Delaunay, a modern Hercules, an acrobat by profession, whose chapped hands were simply licked by his rabid dog. On the same day a young man, Léon Schan, of Paris-Belleville, was bitten rather badly by the same dog. Schan underwent the preventive treatment from March 29th to April 7th, 1889, and is still in good health. Delaunay died of furious rabies in the month of May last. The same dog bit other dogs, and it is a fact that one of the latter became rabid on April 12th, and bit two persons, Mrs. Lacasse and Mr. Fanconnier. They were inoculated from April 12th to May 2nd, and are now quite well.

"3. Eight persons belonging to the France family, the father, mother, and six children, were bitten at St. Martin des Olmes, in the Puy de Dôme. One of the children died of rabies on January 1st. The seven others at once left to be inoculated, and are quite well now. Three oxen, two dogs, and one cat bitten by the same dog, died of rabies in the second month after being bitten.

"4. On June 1st and 2nd, 1889, eight persons hailing from Vaucluse were bitten by the same dog. Six of them submitted themselves to the anti-rabic treatment, and are now quite well. Two declined to be inoculated, and both died of rabies, one on July 1st, and the other on July 2nd.

"5. Pierre Butte and his wife were licked on open wounds. The wife declined to be inoculated, and died of rabies. Butte, on the other hand, was inoculated and is now quite well."

The CHAIRMAN then proposed a vote of thanks to Dr. Ruffer, which was carried unanimously.

Correspondence.

SCIENTIFIC AND TECHNICAL INSTRUCTION IN ELEMENTARY SCHOOLS.

Mr. Martin Wood has forwarded for publication the following reply from the Right Hon. A. J. Mundella, M.P., to a query he addressed him on the subject of additional expenditure which would be involved in any attempt to carry out the subjects for improved education put forward at the meeting of Wednesday, 27th Nov.:—

"In answer to your first; twenty years ago children entered the mills as half-time workers at eight years of age. There was the same objection to raise the age all round to ten as there is to-day to raise it to twelve. If half-time began at twelve, or even at eleven, and full time not earlier than thirteen, although I should hope ultimately to make it fourteen, there would be some chance of a good, sound, elementary education for our rising youth. I would superadd continuation schools for evenings up to seventeen or eighteen. This would bring us abreast of the best Continental systems.

"2. Parents in Germany and Switzerland earn lower wages than in England, yet they gladly make the sacrifice in the interests of their children. The difficulty is with the first child, delaying its earnings for two years. After this, they follow on in due course, and all the family profits by the thrift and self-denial of the parent. Moreover child labour is not so much in competition with adult labour. This is an important factor in the case.

"3. As to the funds for improving the teacher, and extending education. Re-adjust taxation, let those who have large incomes contribute a little more than they do now. The Swiss say, 'good education is the security of the rich, and the best inheritance of the poor.'"

Eastwood, Staleybridge, 30th Nov., 1889.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings. at Eight o'clock:—

DECEMBER 11.—H. TRUEMAN WOOD, M.A., Secretary to the Society, "The Paris Exhibition." SIR PHILIP CUNLIFFE-OWEN, K.C.B., K.C.M.G., C.I.E., in the chair.

DECEMBER 18.— SIR ROBERT RAWLINSON, K.C.B., "London Sewage." Professor SIR HENRY E. ROSCOE, F.R.S., M.P., in the chair.

CANTOR LECTURES.

Courses of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

WILLIAM JAGO, F.C.S., F.I.C., "Modern Developments of Bread Making." Four Lectures.

LECTURE III.—DECEMBER 9.—*Bread Factories and Mechanical Appliances.*—Requirements in a perfect bread factory or modern bakehouse.—Sanitary arrangements.—Provisions for the control of temperature, and other details.—Examples of bakeries on modern lines.—Mechanical appliances.—Flour-blending machines.—Flour-sifting machines.--Dough-kneading machinery, various types.—Water-gauging and attemperating appliances. — Dough-dividing machines.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, DEC. 9...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. William Jago, "Modern Developments of Bread-making." (Lecture III.)

Farmers' Club, Salisbury-square Hotel, Fleet-street, E.C., 6 p.m. Mr. L. B. S. Druce (Secretary), "The Education of those Intended to be Farmers."

Surveyors, 12, Great George-street, S.W., 8 p.m. Discussion on Mr. E. Ryde's paper, "The Tithe Question with Suggestions for the Redemption of the Rent-charge."

Geographical, University of London, Burlington-gardens, W., 8½ p.m. 1. Sir W. Macgregor's account of his Journey to the Summit of the Owen Stanley Range, New Guinea. 2. Exhibition of Lantern-slide Views, by Mr. A. P. Goodwin, a member of the Expedition.

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Rev. Prof. Skeat, "English Spelling and Pronunciation."

TUESDAY, DEC. 10...Farmers' Club, Salisbury-square Hotel, Fleet-street, E C., 4 p.m. Annual General Meeting.

Medical and Chirurgical, 20, Hanover-square, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Professor Osborne Reynolds, "The Triple-Expansion Engines and Engine Trials at the Owens College, Manchester."

Photographic, 5A, Pall-mall East, S.W., 8 p.m.

Anthropological, 3, Hanover-square, W., 8½ p.m. 1, Mr. Edward Beardmore, "The Natives of Mowab, Daudai, New Guinea." 2. Mr. S. B. J. Skertchley, F.G.S., "Fire-making in North Borneo." 3. Dr. H. Rink, "The Origin of the Eskimo."

Colonial Inst , Whitehall-rooms, Hotel Métropole, Whitehall-place, S.W., 8 p m. Mr. Matthew Macfie, "Aids to Australian Development."

Horticultural, 1 p.m.

WEDNESDAY, DEC. 11...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. H. Trueman Wood, "The Paris Exhibition."

Microscopical, King's College, W.C., 8 p.m. Mr. A. W. Bennett, "The Freshwater Algæ and Schizophyceæ of Hampshire and Devon."

Pharmaceutical, 17, Bloomsbury-square, W.C., 8 p.m.

Royal Literary Fund, Adelphi-terrace, W.C., 3 p.m.

Inventors' Institute, 27, Chancery-lane, W.C., 8 p.m. Discussion on the Resolutions passed at the recent International Congress on Industrial Property; and other matters connected therewith.

Sanitary Institute, 74A, Margaret-street, W., 8 p.m. Mr. W. Santo Crimp, "The Disposal of Sewage."

Central Chamber of Agriculture (at the HOUSE OF THE SOCIETY OF ARTS), 11 a.m.

THURSDAY, DEC. 12...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 6 p.m. Mr. E. Muybridge, "The Science of Animal Locomotion in its relation to Design in Art."

Electrical Engineers, 25, Great George-street, S.W., 8 p.m. 1. Annual General Meeting. 2. Adjourned discussion on Mr. G. L. Addenbrooke's paper, "Electrical Engineering in America."

Mathematical, 22, Albemarle street, W., 8 p.m.

FRIDAY, DEC, 13...Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. John Hale, "Hydraulic Station and Machinery of the North London Railway, Poplar."

Astronomical, Burlington-house, W., 8 p.m.

Quekett Microscopical Club, University College, W.C., 8 p.m.

Clinical, 53, Berners street, W., 8½ p.m.

SATURDAY, DEC. 23...Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Journal of the Society of Arts.

No. 1,934. Vol. XXXVIII.

FRIDAY, DECEMBER 13, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

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CANTOR LECTURES.

The third lecture of the course on "Modern Developments of Bread-making," was delivered by Mr. William Jago, F.C.S., on Monday evening, 9th inst. The lecturer completed his remarks upon yeast, and then proceeded to describe the arrangements of bread factories and the mechanical appliances now adopted.

The lectures will be printed in the *Journal* during the Christmas recess.

FOREIGN & COLONIAL SECTION.

A meeting of the Committee of the Section was held on Thursday, December 5th, at 4 p.m. Present:—Admiral Sir Erasmus Ommaney, C.B., F.R.S., in the chair, Major-General Sir William H. R. Green, K.C.S.I., C.B., Major General Hamilton, and Mr. C. M. Kennedy, C.B., with Mr. H. Trueman Wood, Secretary of the Society, and Mr. Edward Cunliffe-Owen, C.M.G., Secretary of the Section.

The programme of papers to be read during the present session was discussed.

INDIAN SECTION.

A meeting of the Committee of the Section was held on Monday, 9th inst., at 4 p.m. Present:—Sir George Birdwood, M.D., K.C.I.E., C.S.I., in the chair, Major-General Sir Owen Tudor Burne, K.C.S.I., C.I.E., Mr. Hyde Clarke, Sir Henry S. Cunningham, Major-General Sir Frederick Goldsmid K.C.S.I., C.B., Mr. Thomas H. Thornto D.C.L., C.S.I., with Mr. H. Trueman Wood, Secretary of the Society, and Mr. Demetrius Boulger, Secretary of the Section.

The programme of papers to be read during the present session was discussed.

Proceedings of the Society.

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FOURTH ORDINARY MEETING.

Wednesday, December 11, 1889; Sir Frederick Abel, C.B., D.C.L., F.R.S., D.Sc., Vice-President of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Dent, Clinton T., F.R.C.S., 61, Brook-street, W.
Furneaux, Henry John, Boxgrove-house, Forest-hill, S.E.
Higgins, Samuel, 12, Finchley-road, St. John's-wood, N.W.
Purves, David, Ferro Dene, North Dulwich, S.E.
Wright, Ebenezer, Gloucester-house, Red-hill, Surrey.

The following candidates were balloted for and duly elected members of the Society:—

Black, Surgeon-Major William G., F.R.C.S.E., M.R.C.S., 2, George-square, Edinburgh.
Brooke, Walter, St. Helier, Dynevor-road, Richmond, Surrey.
Compton-Smith, William Compton, 23, Sumner-place, South Kensington, S.W.
Ellis, Basil Pym, 9, Southwick-crescent, Hyde-park, W.
Flint, Charles A., 12, St. Helen's-place, E.C.
Harrison, William J., 7, Carteret-street, Westminster, S.W.
Lorenzen, Christian Carl, 149, Minories, E.
Smyth, William Stopford, Newport, Monmouthshire
Sutton, Joseph W., Sunnyside-cottage, Thames Ditton.
Thomas, Joseph, Engineer's Office, Royal Victoria Docks, E.
Thompson, Thomas William, Eastham Ferry, near Birkenhead.

The paper read was—

THE PARIS EXHIBITION.

By H. Trueman Wood, M.A.,

Secretary to the Society.

As the Society was good enough to allow me to devote a considerable portion of my time during the past eighteen months to the service of the British Section of the Paris

Exhibition, I am specially anxious to render it some account of the great work with which I have had the good fortune to be connected, and I have therefore to thank the Council for readily according to me the permission which I sought, to read this evening, before the Society of Arts, a paper on the great French Exhibition of 1889.

It has ever been the fashion to surround the origin and preparation of an Exhibition with a blaze of anticipatory congratulation. This, however, was not so with the one just closed. We must all remember what dire forebodings accompanied its birth. The year was of course an unfortunate one. Perhaps less unfortunate as a centenary than any of its four or five successors, but still by no means a reassuring date. An unlucky expression to the first circular issued to foreign powers gave reasonable cause for belief that the French Government, and the French people, had it in their minds to celebrate and emphasize the Revolutionary idea in its most violent and most objectionable form.

With one consent the monarchical Governments of Europe refused to take any share in the Exhibition. Many doubted whether it would be held. One Prime Minister publicly expressed a doubt whether the property of foreign exhibitors would be safe in the French capital. In vain the French representatives, at home and abroad, disavowed the sentiments attributed to them; in vain they declared—and as the event proved with perfect truth—that the Exhibition was wholly apart from political parties and revolutionary centenaries. The impression had taken firm hold, and could not be removed. Some States were actually unwilling to take part; others were not sorry for an excuse to stand aside. In our own case there can be no question that our official co-operation would have made this country once more most popular in France. Grateful as the French Government were to us for the part we did take, it is certain—and no one could spend six months in Paris without appreciating the fact—that the abstention of our Government produced a soreness which was not caused by the absence of any other nation. With the remembrance of 1878 in their minds, it was natural that the French, and especially the Parisians, should feel more keenly a slight from England in such a matter than one from any other source.

For what the French administration had declared all along came perfectly true. As soon as the Exhibition began to occupy men's minds—some time before it was actually open—the centenary fell into the background, was almost forgotten. They need not after all have been afraid to have opened on the 1st of May. Nobody this past year has been thinking about the fall of the Bastille or the meeting of the States General. The various centenary celebrations passed off as quietly as any other holidays, offering opportunities for illuminations, fireworks, and military reviews, but for nothing more. The reproduction of the Bastille attracted visitors in the same fashion, but to a less extent, than the reproduction of Old London in the Health Exhibition, and had a popularity about on a par with that of the Spanish bull-ring which was set up next door to it. And so with the other few spectacles drawing their interest from the centenary. They attracted, as shows, their small proportion of the vast crowd of idle Paris sight-seers, but their political associations were altogether forgotten or put aside.

The Exhibition seemed to occupy public attention to the exclusion of everything else, and the fact that it had once been considered as merely a part of the celebrations of the centenary year was forgotten before it had been open a week. Nor was it only the memory of the Revolution that it pushed aside. It postponed, at all events, the civil commotion which everybody was expecting, and which that general expectation would certainly have brought about. It tided over what would have been a period of great electoral excitement. It helped to rid the country of a pretender who certainly, whatever other benefits he offered did not propose to include among them the benefits of peace, and it ensured, at all events for a short space, the advantages of quiet and stable government for France.

Whether it has done more than this remains to be seen, but it looks as if France had indeed learnt the blessings of peace and quiet; as if the crowd of provincials which flooded the capital from May to November had infused into the Parisians something of their own good sense and prudence; as if the effect of the Exhibition would survive the short period of its duration. To borrow the words of a brilliant writer in the *Temps* :—

> "Cette impression durera-t-elle ce que dure une impression, ou survivra-t-elle, au contraire, à la cause que l'a fait naître dans les esprits ? Voilà qui dépend, à vrai dire, de nous, et non des autres. Si nous recommencons dans notre politique intérieure la série des erreurs et des fautes qui avaient failli compromettre le succès de l'Exposition, l'étranger

se hâtera de dire que nous avons su sauver les apparences pendant une trêve de six mois; mais que, pécheurs incorrigibles, nous sommes retournés à notre vomisement, aussitôt éteints les lampions du Champ de Mars. Défendons mieux que cela notre bonne renommée si vaillamment et si galamment reconquise. Sachons prouver au monde que six mois de sagesse ne représentent pas le maximum d'effort que nous puissions faire."

That it may turn out so, that the Exhibition may prove to have been something better than a toy which has amused a fractious child for a few hours, and kept him out of mischief for the time, must be the sincere desire of every friend of France.

It is, however, not so much the political effect of the Exhibition that we are probably most interested in this evening. It has been universally acknowledged that its founders, had they been gifted with superhuman foresight, could not have devised any better remedy for the political ills from which France was suffering. It may be admitted with equal readiness that it has done much to restore to the French people that confidence in themselves which they have never ceased to profess, but which in their inmost hearts they have lately nearly lost.

The discussion of the industrial results is less easy. As regards pecuniary profits, they are certain. Far more than enough foreign gold has flowed into France to replace all that she sent out into the swamps of Panama. Of course it all went to Paris, but a great deal of it must have passed on to enrich the workers of the country. I will not weary you with figures, but merely say that statistics of every sort, customs, octroi, the traffic returns of railways, the reports of the internal communications of Paris, the register of hotels and lodgings, all confirm, if confirmation be wanted, the impressions produced by a visit to Paris itself. It has been calculated that between six and seven millions of persons came to Paris for the Exhibition, of whom some million and a half were foreigners.* At a very moderate calculation of individual expenditure, this must have meant some 50 millions sterling expended in Paris in return for the State and municipal contributions of about £700,000. And besides this there was all the money expended on the Exhibition itself, a large proportion of which came from foreign sources.

It has been said that all the money went to hotel and restaurant keepers, to the proprietors of places of amusement, and similar classes But this is certainly untrue. Every trade in Paris must have profited by the Exhibition; work was abundant, even the lowest and idlest class, for once, seemed busily engaged. Shopkeepers of every sort must have made money out of the teeming population which crowded every corner of Paris. One does not see that the professional classes can have derived much direct profit from the Exhibition, but they must have benefited from the increased prosperity of their clients. And the benefit must have been felt far beyond the capital. Not only did workers throng into Paris from every district of France, but a great impulse was certainly given to many manufacturing industries by the preparations for the Exhibition—both buildings and contents.

So much benefit the French have already reaped; what advantages may they look for in the future? Individual traders have in many cases increased a growing reputation or laid the foundations of a new one. France has shown the world the condition of her industrial resources, and the world has unquestionably been impressed. She has probably done not a little to develop fresh markets for her wares, especially in the East and in South America. Complaints have been heard of late that much of the business with Eastern nations which used to be transacted in London is now transacted in Paris. Those complaints will be louder than ever after the Exhibition. The Governments of Spanish America saw their opportunity in Paris, and voted large sums for their representation there. They will certainly get all their money back with interest. The development of those countries will be effected largely through French agencies and by French capital, and the profits will go to France. The industrial prestige of France has been greatly raised by the Exhibition, and it is hardly possible but that her merchants have profited by the large influx of foreign men of business to make fresh connections and open out new lines of commerce.

On the whole it is probable that, looking at the matter from a purely commercial standpoint, no nation ever made a better investment of a million and a-half of money than France did with this Exhibition. She got her money back 25 or 30 times over in six months. She obtained what a trader would call a magnificent advertisement, and she started a large amount of fresh business of a profitable and improving character.

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* 150,000 Americans are said to have come over this summer. Half a million passengers were taken from London to Paris.

It may be interesting to consider what was the actual cost of the Exhibition, and how that cost was met. The responsibility was divided between the State and a syndicate or society established for the purpose. From calculations based on the experience of 1878, it appeared that the total cost might amount to £1,720,000. A possible receipt of £760,000 was allowed for. The deficit of £960,000 was covered by a State contribution of £680,000, and a subsidy of £320,000 from the city of Paris. Instead of waiting until the receipts accrued from the payments at the gates, the administration preferred to raise money at once upon their expectations. For this purpose, first of all, a Guarantee Society was formed, which advanced a sum of £760,000 on the security of the receipts.

The guarantors were afterwards bought out by the Crédit Foncier for the amount of £860,000. To cover this, the Crédit Foncier issued bonds to the extent of £1,300,000, the bonds to be repaid (with the chance of money prizes of considerable value) at periodical drawings, and all to be repaid within a period of 70 years. In addition, each bond, the value of which was 25 francs, had 25 admission tickets attached to it, so that by this proceeding the Crédit Foncier raised a sum of £1,300,000, issuing at the same time 32 million tickets.* The scheme took amazingly —the chance of a prize, the certainty of repayment, with the tickets thrown in as a bonus, attracted the speculative instincts of the French investing public; the money was subscribed seven times over, and the bonds went to a small premium at once. The idea was a very clever one, and extremely well worked out, but the investors overlooked, or thought immaterial, the certain depreciation of the value of the tickets when such an enormous number was thrown on the market at once.

The natural result followed. The day after the opening, tickets nominally priced one franc were selling for 75 centimes. They soon sank to 50, and even fell as low as 25.† One might suppose, had this very obvious result been foreseen by the promoters of the scheme, they would, as they very well might, have issued a smaller number of tickets with each bond, for there is no doubt the bonds would have been taken up with equal readiness.

The cheapness of the entrance fee had a distinctly unfavourable effect on the class of visitors, and certainly, while it raised the numbers, it lowered the general character of the crowds. That so many of even the poorest class had an opportunity of enjoying so much pleasure, and gaining so much useful instruction, was an unmixed good, and in democratic France the boon was fully appreciated; for the poorer class felt that the Exhibition was as much their property as it was that of the wealthier, intended as much for their benefit as for that of the rich. But the real advantage could equally well have been obtained while giving others a chance of examining more quietly and more leisurely the wonderful collection of artistic, scientific, and industrial wonders than they could enjoy in the midst of a dense and restless crowd. The principle adopted in recent English Exhibitions, of keeping one day a week at a higher rate of admission, is fair to everybody. It gives exhibitors a better chance of doing business, and visitors who really want to study the contents of the Exhibition a better chance of doing so.*

But had the prices been higher, the Exhibition would have been less popular and therefore less serviceable to the country. And popular to an enormous extent it certainly was. Great as were the number of foreigners attracted to Paris by the Exhibition, the main bulk of the visitors were French people, and poor French people. A most interesting sight it was to see, on a fête day, the crowds of poor folk picnicking in every corner of the grounds, filling up every available seat, enjoying themselves with a modest meal of bread and sausage and thin wine, which they were allowed to partake of wherever it so pleased them without hindrance from the authorities.

It is true that the executive were forced to cater for their principal customers. They allowed small kiosks, which were practically cheap drinking bars, to spring up all over the grounds. Stalls for the sale of cheap toys and sham jewellery were located in the most unsuitable places, and with most unnecessary abundance. As these sort of things seemed to gratify the visitors more than the more serious parts of the Exhibition, possibly the administration were right in their judgment, but their action in this respect did not tend to raise the character of the Exhibition generally.

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* Of these some 30 million were sold. The total number of admissions was 28,122,075, of which 25,398,609 were by payment, and 2,723,460 gratuitous. The number of tickets sold does not correspond with the number of entries, because at certain hours and on special days more than a single ticket was required for each visitor.

† For three weeks after the close tickets were sold as a means of entrance to the Champ de Mars. 111,332 of these were sold up to Nov. 30th, on which day they were selling at two sous apiece.

* In our own Exhibitions the requirements of the least wealthy class of visitors were met by the arrangements for the combined railway and admission tickets, by which the actual cost of admission was greatly reduced.

Still, however great the crowds, and the numbers frequently exceeded the quarter million, there was never any trouble in maintaining order. The crowds were always tractable, always well-behaved. There was no drunkenness, no disorder, everybody always seemed good-humoured and happy. Perhaps because the majority of the visitors offered but poor attraction to such gentry, even the pickpocket seemed rare, though his absence may also have been due to the heavy punishment meted out in France for crimes of this sort. Certainly there was singularly little additional work created by the Exhibition for the Parisian police courts.

Of the system adopted at the entrances, not much that is good can be said. Its only advantage seemed to be that it suited what some ill-natured critics assert to be the French ideal of using the greatest number of individuals to do the smallest amount of work. You had to buy your ticket from an obtrusive hawker in the street, who made you pay just what your ignorance of the language or the benevolence of your appearance justified him in asking. You presented it to one official, who clipped it, and to another who took it, and as the crowd of visitors were for the most part ignorant of the routine, the result was that you often had to stand in a long row, one end of which slowly filtered through the wicket, while the other end lengthened itself out by new arrivals.

It certainly would appear to be simpler to let the crowd pass through turnstiles, paying their francs or delivering up their tickets as they went, but this method would not have provided for the raising of funds beforehand, or have afforded the opportunity of a lottery with the attractive gambling element.

Nor is the device of requiring that the owner's photograph should be attached to a permanent ticket as convenient in practice as it is excellent in theory. It gives a great deal of trouble, and though it unquestionably does prevent personation, it does so at too great a cost both to the administration and to ticket holders to make it worth adoption.

On the other hand, the arrangement for workmen's tickets was excellent. It is, of course, impossible entirely to prevent fraud with these tickets, but the French plan (which was adopted with success at the recent South Kensington Exhibitions) of a ticket with a series of dated spaces, in each of which a punch mark was made as the ticket was used, was as practical and as good as any.

In the financial result, it appears that the expenditure has been kept down below the estimate, and that it will not exceed £1,660,000. The difference between this sum and the amount originally estimated for is to be returned to the Treasury, which will therefore only be called upon to find £360,000 instead of £680,000.*

The whole of the money spent on the Exhibition, that is its actual total cost, it would be impossible to calculate with even approximate accuracy. I believe that the South American States authorised an expenditure amounting to nearly half a million. The other foreign Commissions certainly spent half as much, and, if we give each of the 50,000 exhibitors an expenditure of £10 only (a very low estimate), we get another half-million. We may, therefore, take it that the great show cost in its entirety something over £3,000,000 sterling. In this connection it may be interesting to note that the total cost of all the London International Exhibitions, since and including 1851, may be roughly put down as something under £2,000,000 (of course, this refers to official expenditure only), or rather more than the amount (£1,600,000, as above stated) spent this year by the French administration.

The buildings as a whole were certainly and beyond all dispute finer than those of any previous exhibition. Indeed, they were too good for their purpose. It has often been the practice to make a certain portion of an exhibition permanent, while the remainder was of a construction just sufficient to last for the time it was wanted. Thus, 1855 gave Paris the Palais de l'Industrie, 1878 left the Trocadéro behind it; the Rotunda in Vienna is a relic of 1873, and certain of the buildings at South Kensington are remains of 1862; but all the chief buildings in the Champ de Mars are built this time as if for permanent use. The vast machinery hall is as well built as a London railway station, and will presumably last as long. The great flanking buildings at the side, the Palais des Beaux Arts, and the Palais des Arts Libéraux are only less solid, and the wide ranges of courts which connect these and the machinery hall, though slighter, will doubtless last the life of an average modern building if it be decided to keep them up. The effect was splendid, but it was very costly. It could never have been obtained in this country, where we expect exhibitions to pay for themselves, since no amount of money likely to be received for admissions would have sufficed to cover the cost. Such a result could only be attained by liberal contributions from a government or a municipality which should be content to be repaid indirectly, as France was, and Paris was, over and over again.

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* The credit side of the Exhibition balance-sheet has been approximately drawn up as follows:—Amount of guarantee received from the "Crédit Foncier of France," 21,500,000 frs.; produce of sale of land to *restaurateurs*, exhibitors, and various trades-people, 2,000,000 frs.; estimated sale of materials of construction, 1,000,000 frs.: State subsidy, 18,000,000 frs.; and City of Paris subsidy, 7,000,000 frs. These sums amount in the aggregate to 40,500,000 frs., or £1,980,000 sterling. The expenditure, which had been estimated at a total of 43,000,000 frs., has only amounted to 41,500,000 frs., which leaves the surplus of 8,000,000 frs. already referred to.

Certainly it is a question whether it is not an economical way of obtaining public buildings. A fine permanent structure is set up instead of a temporary one, and the city gets the building for the cost of the difference between the two.

It was a great drawback to the arrangement of the Exhibition that it was cut up into three distinct and separate parts. The Trocadéro was separated from the Champ de Mars by the river and by a wide road beyond it. To get from one to the other you had to cross the long Pont d'Jena, and then to pass over a raised bridge above the road. As a result, when the crowds were greatest, as on a fête night, communication was absolutely interrupted, and at no time was the Trocadéro as much utilised as it would have been had it been more accessible. The Champ de Mars and the Esplanade des Invalides were joined by a range of buildings some three-quarters of a mile long, the main connecting link being the narrow gauge railway running by the side of those buildings. Practically these two parts of the Exhibition were entirely separate and independent; they did not support or aid one another's effectiveness in the least. The real magnitude of the Exhibition never impressed itself on the spectator, who could never obtain a view from any one point embracing the whole. Had it been possible for a site to have been found on which the whole could have been concentrated, then indeed would visitors have appreciated what a gigantic undertaking the Paris Exhibition of 1889 really was.

And looking at the results which were achieved within limits which, compared with the conceptions of the organisers of the Exhibition, were really narrow, one wonders what those skilful administrators would have produced had they been granted a little more margin of space; had they been able to thrust back their buildings a little, so as to give a wider central garden or park, to surround them with an outer circuit of garden; at least to relegate to some other position the crowd of smaller buildings which, interesting and admirable in themselves, detracted somewhat from the appearance of the main structures.

As it was, one could not but admire the admirable skill with which all available space had been utilised, and regret that more space had not been available. More open ground, more space over which crowds could pass to and fro, was really wanted for the immense number of visitors, and that is just what is not to be had in the centre of Paris. Perhaps in no other city could so much space have been obtained in the same way, for where else would it be permitted to stop up roads, divert trams and omnibuses, and even utilise a wide and important thoroughfare as a site for the erection of a mile of buildings?

One feature of the whole was the number of separate comparatively small buildings. In so great numbers they cannot be considered a desirable feature. Crowded together, and ill-placed, they lost their effect, and as regards the amount of space afforded for exhibits, they were obviously wasteful. Those in the Champ de Mars belonged for the most part to the States of Spanish America, and their existence was to a great extent forced upon the administration by the necessity of finding additional space after all that in the main buildings had been disposed of, and by the wish to meet the views of the representatives of those States who were desirous of erecting separate pavilions in which the better to exhibit the resources of their several countries. Some of these pavilions were among the most attractive buildings in the Exhibition, but they required to be more largely distributed, and to be set off by surrounding space. These and many other erections encroached on the garden space despite the energetic efforts of M. Alphand, the Director-General of the Works, whose long experience had taught him the value of open ground where crowds are, and who fought foot by foot for the garden he had evolved out of the arid waste of the Champ de Mars.

Of the beauty and magnificence of the buildings themselves I have heard but one opinion. Never before have been seen such examples of iron construction, admirable in design, excellently suited for their purpose, beautiful in appearance, and frankly illustrative of their material and method. Whether you considered the mighty tower, so much scoffed at and so much admired, or the great machinery hall, a marvel most to engineers who could appreciate the skill of its design and its execution, or all the various buildings which extended between the two, you were struck by the ingenuity which had raised beautiful structures out of the ugliest of building materials, and by the skill with which, in very various manners, that material had been applied.

Of the tower itself there is little need for me to speak. It has been so frequently and so fully described that it must be almost as familiar to those who have never left London this year as to those who passed their summer in its shadow. Whether it did more to popularise the Exhibition or the Exhibition did more to popularise it is a point which those may discuss who choose. It is certain that to each was due a large share of the success of the other, and that neither without the other would have attracted the crowds which were drawn together by the two conjointly. May I not be considered wanting in admiration for the structure, or appreciation of the constructor's skill, if I express the hope that M. Eiffel's success may not produce any imitators, or suggest the opinion that one such tower may suffice to supply the needs in this respect of the civilised world.

It must indeed be admitted that the buildings were better than their contents. There were, of course—if a comparison was made with the exhibition of eleven years ago—on every side marks of progress, and there was a very high general average of excellence, but there were but few exhibits either specially attractive to the public from their magnificence, or specially interesting to the expert from their novelty. It is true we are apt to expect too much. Scientific discoveries are now so speedily made public, so rapidly applied to practical use, that for the educated visitor they quickly lose their interest as novelties, and fall into rank among the appliances of daily life. Now-a-days scientific inventions cannot keep pace with the public curiosity for something new and startling. The phonograph in its perfected form had not been in Europe nine months when the Exhibition opened, yet it was hardly looked upon as a novelty in Paris, though it certainly was the great popular attraction* But even after all allowance is made for this state of things, it must, I think, be admitted that in many, if not most, classes of the Exhibition a very much finer show could have been made if some makers who were absent had been present, if some who were present had exerted themselves more to send in absolutely the finest specimens of their work they could produce.

Not, it must be admitted, that the general public is severely critical. It is wonderful to watch the crowd in an exhibition steadily streaming along the galleries, paying not very much notice to the things exhibited, but evidently pleased and impressed by the general effect. Pictures are always popular, so is moving machinery; in fact anything in motion attracts a crowd, but a glass case filled with the finest examples of the weaver's or hosier's or brass-finisher's skill, standing in the midst of a hundred other glass cases like unto itself, has singularly small attraction for the casual sightseer.

This, however, applies to all exhibitions. Certain classes of goods attract notice from the public, certain others are shown for the benefit of persons interested, who then have an opportunity of comparing together the goods of different manufacturers, the productions of different countries.

The Paris Exhibition was certainly less fortunate than some of its predecessors in having exhibits of commanding importance, and as a proof of this may be mentioned the fact that the adjudicators of the prize of 100,000 francs (£40,000) offered by M. Osiris for the most important exhibit, could find nothing better than the great machinery gallery, which was not an exhibit at all, to receive their award.

In the case of foreign nations much allowance must be made for the circumstances surrounding the origin of the Exhibition, and it must be remembered that very few foreign exhibitors can have been certain, until a very short time before the Exhibition, whether they would take part in it, or not. Even in France, the prevalent uncertainty is believed to have kept back some exhibitors, and prevented others from putting so much heart into their preparations as they otherwise might have done.

But the general result was certainly to exalt France over her rivals. In every Exhibition, the country where the Exhibition is held is expected to play a more prominent part than all the other nations put together. In Paris, however, there was a wider difference than usual between native and foreign productions, for no nation can be said to have been adequately represented, and some made a very poor show indeed.

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* The average number of daily auditors was 20,000; sometimes it rose to 30,000.

France certainly showed evidence of great industrial progress since 1878, so great indeed that I have heard it not unfrequently remarked upon with surprise by men who I should have thought were perfectly familiar with the industrial resources of the country, and the development they have attained in recent years. The advance, too, made in education was equally well illustrated, and impressed in like manner those best qualified to give an opinion.

It was originally proposed that the whole Exhibition should be arranged by classes of exhibits, not by nationalities, that is to say, that the contributions of each country should be distributed into their places according to classification. This idea naturally proved quite impracticable, and was abandoned at a very early stage of the organisation, but a modified attempt at a classification was made, and space was allotted to the different contributing countries in the separate buildings intended for the separate groups of exhibits. For instance, our space was in five divisions: fine arts, general industries, liberal arts, machinery, agriculture and food, these last two being placed together. Besides this, we had exhibits in the railway section, in the social economy section, and in the "retrospective" part of the Exhibition. The nature of the case requires that pictures and machinery in motion should be in special buildings, but the further division adopted in the present instance made the administration of a foreign section additionally costly and difficult, besides greatly minimising the effect produced by the contributions of each country. Supervision over five courts, separated by intervals of as much as three quarters of a mile, was more than difficult; a larger staff was necessary, with consequent additional cost; and there were many items of expenditure which might have been economised had the old system been adopted. It is true that there was an advantage to the visitor desirous of inspecting a particular class of products, but in practice the advantage was very slight, and indeed there were not many classes in which the arrangement could be trusted to be any help at all.

Coming to the manner in which the exhibits themselves were arranged in the French courts, there is much to admire in the system adopted. The arrangements for each class were placed in the hands of a committee, or "Jury d'Admission." They decided in the first instance who should be admitted, and allotted the space among the selected applicants. They also settled the decorations of the court, and adopted a uniform design for show-cases. The cost of all this, together with the charges for maintenance, was divided among the exhibitors in proportion to the space occupied. This, it will be seen, came to precisely the same as charging a rent for space, and in estimating the total cost of this Paris Exhibition in comparison with that of other exhibitions a considerable proportion of the large sum paid through these committees should be included. It is to be remembered that the exhibitors had all their private charges for installation and maintenance to defray; the only item of which they were relieved was the cost of show-cases. So far as I could ascertain, the actual cost to exhibitors in the French and English courts was not very different, though we had to defray the costs of administration out of what the exhibitors paid us.

The result of these arrangements in the French courts was certainly good. In some courts the effect was extremely attractive; in others the appearance was too monotonous. As a whole, the exhibitors seemed satisfied with the plan, though some of the more enterprising objected, and with reason, that it reduced them all too much to a dead level, and discouraged legitimate rivalry. In the foreign courts, where exhibits of different classes were placed in close proximity, such a plan could not be carried out.

A most important point, as regards the success of an exhibition, is the method of catering. At Paris the arrangements were on the whole very good. There were restaurants of all classes; some of them were as good as the best of the boulevard restaurants, and not much dearer. There were plenty of restaurants at fixed prices, and there were several large bouillons. Below these again, there were numerous kiosks and small pavilions where cheap wine, bread, sausages, and other inexpensive articles of food could be had. The poorest or most economical class of visitors brought their supplies in with them, and no hindrance was placed in the way of their picnicking about the grounds. All classes, therefore, were provided for. The restaurants were well placed, most of them along the ground floor of the buildings looking into the gardens, and others in separate buildings. The way in which the concessions were disposed of was ingenious and perfectly fair; the spaces were plotted out, and a reserve price—so much per 1,000 visitors per square metre of space occupied—placed on each plot. ' They were then put up to public auction. When the Exhibition was flooded with cheap visitors the restaurateurs objected, and to avoid dispute it was agreed that the contracts should be taken as based as upon 13,000,000 visitors, the number in 1878.

The question of juries and awards is a very difficult one. When, in 1851, the jury system was elaborated, a system be it said which has been but slightly modified since, and not at all improved, nobody had any idea of the trade or advertising value of exhibition medals. They proved, doubtless in consequence of the care with which they were awarded, of very great value indeed, and a natural demand for them arose which in due course produced a supply. Then the thing got overdone, and the larger firms—who, it may be remarked, had got as many medals as they required—began to look upon exhibition awards with distrust, and with a certain contempt. The esteem in which they were held was not increased by the ingenious plan adopted at certain provincial exhibitions of issuing what may be termed assignats for medals, diplomas representing medals. The jury awards were, under these circumstances, not hampered by any special regard for economy. Juries felt they could afford to be liberal, and they were.

A different course of action was adopted by the promoters of the Manchester Exhibition of 1887, who were sensible and courageous enough to announce they would have no jury awards at all. Rather to their surprise they found their decision was cordially welcomed by the exhibitors generally, and gave general satisfaction. A similar course was equally successful in Glasgow the following year. It might have been wished that Paris had followed suit, but it was thought that to have abolished jury awards would have been an unpopular step. In answer to a suggestion which I made myself to the Director-General on the subject, I received the perfectly just reply that he doubted if many of the other foreign Commissioners would agree with me in desiring that no medals should be given.

Having decided to make awards, it is distinctly to be regretted that the administration thought it necessary to economise on the price of the medals, and substituted for them diplomas, nominally equivalent to the three classes—gold, silver, and bronze. The enormous sums brought into Paris by the Exhibition might surely have justified an expenditure which in 1878 was met as a matter of course.

Perhaps, however, we may look on the new system as a step towards the abolition of medals altogether. The objections to them are manifold. With all the good will in the world, it is impossible to award them fairly. First, they ought to be awarded either on practical tests, or on the evidence of experts having practical experience of the machine or goods in question. To do this for thousands of exhibitors in the two or three months available for judging is ridiculously impossible; such a task would take a year or two, and would cost as much as all the other expenses of the exhibition put together. In the hopelessness of such an attempt awards are given on public reputation; on the personal knowledge of the jurors; on such information as can be obtained; on general impressions. As a rule, thanks to the knowledge and painstaking of the jurors, the awards represent fairly well the merits of a firm's productions, but nothing more than this.

As regards the way the work was done at Paris, I should wish to bear the strongest testimony in my power to the impartiality, the honesty, and the laborious care with which the juries discharged their irksome and thankless task. No one but must have been struck with their anxiety to do justice, and with the shrewdness with which, on the whole, they did it; for, on the whole there was not a great deal to complain of. There were some blunders, some miscarriages of justice, but not a great many. The work of the *jurys de classe* was extremely satisfactory.

The duplicate system of appeal, first to *jurys de groupe*, and then to the *jury supérieur*, did not appear to work very well in practice. There was a certain not unnatural impatience at going over again questions which had been presumably thrashed out in the first jury; a reluctance to alter decisions, even on good cause shown—it is true that a great number of appeals with very slight justification poured in upon the upper juries—and, in fact, the theoretical value of the courts of appeal was better than the actual. In practice the system worked unfairly. Those exhibitors who found out their awards, and were dissatisfied, protested. Others had no opportunity. Either the awards should have been made public before the final appeal, or no appeal should have been permitted.

The position taken up by our Government with regard to the Exhibition, placed British exhibitors in a very different position to that which they had occupied in all former great Exhibitions. Not only was financial assistance wanting, but there was an absence of the support attaching to a Royal or even a Departmental Commission. The first great difficulty was an absence of the usual organisation which English manufacturers had always been used to and expected. Without an organisation of some sort, and one possessing a certain amount of strength, and a certain amount of authority, exhibitors would not come forward, and if they did they could hardly, lacking a qualified representative, make the necessary arrangements with a foreign administration.

The difficulty of organisation was solved by the energetic and prompt action of the then Lord Mayor, Sir Polydore De Keyser, and the efficient committee which he formed. The committee was such as to inspire the fullest confidence on the part of the exhibitors, and to carry the necessary weight with the French executive. They could not certainly boast the same authority as a Royal Commission, especially one supported by the personal influence of the Prince of Wales, and guided in all its proceedings by the long experience and consummate tact of Sir Philip Cunliffe-Owen, while they sorely felt in many instances the want of official backing, but short of this they certainly had weight and influence enough to enable them to obtain full consideration for all their requests. There were indeed certain counterbalancing advantages. The private and independent character of the committee often enabled matters to be treated in a less formal and official fashion than is inevitable in what is practically a Government Department, and certainly led to relations not less cordial and friendly than can possibly have existed under any previous conditions whatever. Throughout we all met with the utmost consideration and kindness from the whole French Executive, from M. Tirard, the Premier, and M. Berger the Director-General, down to the subordinates in the various departments, and that this should have been so is not the least among the many sources of pleasant reminiscence connected with the working of the British Section.

The first, and perhaps the most alarming difficulty which met the committee after their formation was the financial one. It was quite uncertain how exhibitors would receive a demand for payment for space occupied, and this was obviously the only source from which the funds could be forthcoming. That the public generally were distrustful of the financial outcome of the experiment was shown by the smallness of the guarantee fund. It was difficult to collect promises amounting to £20,000, whereas two and three hundred thousand have recently been guaranteed for English exhibitions. A careful consideration of ways and means led to the conclusion that a charge of 5s. per square foot over the whole space (omitting gangways) allotted to Great Britain would produce a sum sufficient to cover working expenses on a modest scale. Accurate figures must be left till the publication of the detailed balance-sheet, which will be issued as soon as possible, but there can be no objection to stating the fact that the total revenues of the committee amounted to about £27,500, of which nearly £2,000 were subscriptions, over £3,000 concessions, and about £22,500 rent for space. The total expenses are just, but only just, within the limits of the receipts. It has throughout been the object of the committee to spend the funds with which they were entrusted by the exhibitors for the benefit of those who provided them, not to make a considerable margin of surplus profit. Had they had a larger revenue, they could certainly have utilised it; as it was, they have spent to the best of their ability the funds of which they could dispose. It may perhaps be permitted to contrast their hard case with the more fortunate lot of their predecessors in 1867 and in 1878, who, with grants of £120,000 and £65,000 respectively, were able to deal with matters in a more generous and liberal fashion—in a fashion more satisfactory to those upon whom had fallen the duty of keeping up, on an important international occasion, the credit of their country.

It was at first a great difficulty to know what amounts the committee would really have to deal with, and what expense might therefore with justice be incurred for such items as decoration, a head on which large sums might easily be expended, and the preparation for which had to be put in hand at a early stage of the proceedings. The committee were obliged to begin modestly, and to enlarge their plans as funds came in, a system admirably calculated to check profuse expenditure, but by no means tending to simplify the work of the decorator. In this respect the skilful dispositions of Mr. Donaldson, a member of the committee, who took on himself, as a labour of love, the duty of superintending the whole of the decorative work, were of the greatest service. Probably nobody but a volunteer would have undertaken such a task hampered by such conditions.

There was certainly one advantage in the way the funds came in. For some time before the opening the committee had actually in hand almost the whole of the funds. We were thus enabled to calculate our expenditure exactly, and suit it to the amount of our resources. With any great uncertainty as to our receipts, we could hardly have brought the two sides of the account so near a balance.

In this manner of financing the affairs of a section there is one considerable difficulty. Industrial exhibits can, it has been shown, be made to pay for themselves, but there are important classes of exhibits which cannot. Chief of these is the Fine Art Section. It has been urged, with sufficient lack of generosity, that painters and sculptors, like potters and weavers, should pay the cost of showing their wares. The questions were easily to be argued, were it worth while, but it may be enough to say here that, even granting it not to be unreasonable to ask the painter to bear the cost of exhibiting the picture he wants to sell, it seems hardly fair to expect him to pay costs and charges for a picture he has already sold, and which he must go and borrow from the owner. Now the pictures it is desirable to show are the painter's best, those which have certainly passed out of his possession, not the unsold canvases remaining in his studio. But argument or no argument, the fact remains that without funds for insurance and transport, a Fine Art Section in an Exhibition is impossible if it is to be representative.

The Committee recognised this fact, and considering the attractiveness of a picture gallery, the credit it would bring to the section, and the discredit of its absence, they thought themselves justified in allotting a sum of £1,500 from their general funds to the purposes of the Fine Art Section. This was supplemented by contributions to an equal amount, and with this £3,000 the expenses of the Picture Gallery so universally and so justly admired at Paris, were met.

But, besides the Fine Arts, there are other classes of exhibits which cannot pay their own expenses. It would have been most desirable that the progress which England has made in technical and general education should have been shown to the world at Paris. Ample illustration of this could readily have been provided had funds been forthcoming, and could space—the abandonment of which would have meant serious loss of revenue—have been provided. In this division, consequently, the British Section was conspicuously deficient, and the country lost, in the eyes of foreign educationists, much credit which was justly her due.

When the financial difficulty was overcome, others remained to be faced. The position taken up by the Government had its natural effect on exhibitors. There existed two years ago in this country a want of confidence in the Exhibition which certainly was not to be wondered at, since the French themselves showed no great confidence in their own undertaking. The political outlook was threatening. Doubts were openly expressed whether the Exhibition would ever be opened, and if it were, whether it would not collapse. As evidence of the feeling which existed, it may be mentioned that the British Committee took the very unusual step of insuring its expenses against war or riot; so that, had the opening of the Exhibition been prevented by foreign or internal disturbances, the Executive would have been in a position to return to the exhibitors the amount they had paid in advance for space.

At first, therefore, the demands for space came in but slowly, so slowly that the committee at the time were disposed to adopt a suggestion put forward on behalf of the Institution of Agricultural Engineers, that a large proportion of the British space in the machinery hall should be given over to that Institution. Fortunately for the interests of that Section, the negotiations broke down, and eventually the Agricultural Engineers of Great Britain pledged themselves as a body to ignore the Exhibition entirely. Soon the Exhibition began to be viewed with greater confidence. The magnificent scale on which preparations were made in Paris impressed everybody who went to see for himself what the coming Exhibition would be like. Gradually applications flowed in, and it was soon certain that the we should not only be able to fill up all the space available, but would be able to make a selection which would ensure a fair representation of British industry.

It was even apparent that a much larger space could be filled were it available, but the utmost pressure which the Committee could bring to bear on M. Berger failed to extract an additional foot of space in the buildings from him. It is true that he was overwhelmed with similar applications from all sides, alike from foreigners and from his own countrymen, and it was evident that his pleas of inability were but too well founded.

Then another great difficulty arose. Negotiations had long been going on between the French Government and the Australian Colonies as to the part these latter would take in the Exhibition. It was believed that they had decided not to contribute, and the space which had originally been marked out for them was in process of allotment to British exhibitors. In the late autumn, however, it was announced that New Zealand, Victoria, New South Wales, and the Cape (I give the Colonies in the order of their application) were ready to join in the Exhibition, and on a much larger scale than had been expected. New South Wales withdrew when it was found impossible to meet her views in the matter of space. Victoria and New Zealand consented to make shift with a much smaller amount than they desired. The demands of the Cape being very moderate, it was found possible to satisfy them. The British executive at once altered its allotment plans, and gave back almost all the original Colonial space, while by earnest and persistent efforts a small space of ground was obtained in the gardens of the Trocadéro, on which the Victorian Government was enabled to erect a kiosk for the special exhibition of Victorian wines. By these means the important co-operation of the Australian Colonies was secured. That in the confined space given them—a space insufficient even for the proper display of the exhibits actually sent to Paris—anything like an adequate representation of the natural resources or the industrial capacities of the great Southern continent could be afforded, cannot be for a moment admitted, but it was a great thing to have them there at all, to have England and Australia once more standing side by side, to prove to the world at large how constant is the association, how firm the union between the Older Britain and the New.

To ensure a representation of India was—for different reasons—no more easy a task than to secure space for Australia. Several Indian exhibitors were anxious to show and sell the productions of India, as had been done in recent English exhibitions. The rules of the Exhibition only permitted such sales in a certain portion of the ground set apart for Oriental exhibitors, who were to be allowed to sell wares of genuine Oriental manufacture. After a good deal of negotiation, a site in this locality was offered to the British Committee, on condition that they should arrange for the erection of a building upon it. It was estimated that such a building could not be set up for less than £3,000, and that perhaps £2,000 might be obtained by dividing it into twenty shops, each to be let off at a rental of £100. For the rest, the Indian Tea Districts Association undertook to raise a guarantee fund, out of which the balance of the cost of erection and maintenance should be paid, on condition that the verandah of the building was handed over to them for the sale of Indian Tea. Thus came into being my friend Mr. Purdon Clarke's Indian Palace (or Serai, as he prefers to call it) which has been so important and interesting a feature of the British Section, and of the Exhibition generally. It, and the Ceylon Tea Pavilion, also established through the exertions of the British Committee, have done something to popularise the use of tea in Paris, and have given the Parisians the chance of learning what an excellent beverage is really good tea, properly manufactured and properly infused.

A reference to the British Section would not be complete without mention of our contributions to the Exposition Retrospective de Travail. Of this, one important section relates to methods of transport, and certainly without the contributions from England this section, as regards railway appliances especially, would have been miserably incomplete. The organisation of this part of the Exhibition was distinct from that of the British Section. It was presided over by an independent committee, of which M. Sire, the agent of the Northern of France Railway in this country, was the Honorary Secretary and the active spirit.

A by no means unimportant contribution was made to the Social Economy Section through the instrumentality of a committee, of which Mr. Ernest Hart was chairman and Dr. Parkes honorary secretary.

There were also some English exhibits in the Anthropological department of the Retrospective Exhibition, obtained through the exertions of a committee of which Dr. Garson was honorary secretary.

Of the merits of the British Section as a whole it is difficult for me to speak. To say that it was as good as its predecessor in 1878 would not be true, but it was not much inferior. The space occupied in 1878 was 363,018 square feet; in 1889, 232,845 square feet, or say two-thirds of the amount. In 1878 there were about 2,000 exhibitors in all, of whom nearly 250 were in the Fine Art Section. In 1889 we had 297 exhibitors in the Fine Art Section, and 720 in the other sections, or a total of 1,017. Their quality must be a matter of opinion. The charge for space fell heavily on large exhibitors. In some cases it deterred important firms from entering, as they would not exhibit on a small scale, and shrank from the additional heavy expenditure; in others it limited the amount of space, and consequently diminished the importance of the exhibit. But on the other hand, it had an admirable effect in weeding out the weakest class of exhibitors, and thus raising the average of the whole.

Of the general high quality of the British exhibits unimpeachable evidence is given by the jury awards. Throughout the Exhibition the average of awards to exhibitors was 52 per cent. In the British Section it was 90 per cent., or in the Industrial Section alone 110 per cent. (752 awards among 673 exhibitors). To criticise in detail the whole of the British Section would lead me beyond the limits I have set myself, and indeed the task would be more fitly undertaken by somebody less biased than myself. I may, however, refer to a few of its more important features. First, we filled a much larger space than any other foreign nation. We occupied in the main buildings (the figures previously given include all the various buildings about the grounds except the offices) 218,000 square feet (11,500 of this was Fine Arts). The next largest to this was Belgium with 120,000 square feet, and the United States with 113,000; Switzerland had 65,000, Spain 64,000, Austria-Hungary 32,000.

As regards the merits of our contributions to the various classes. We had a magnificent show of pottery, as is shown by the fact that we took three out of the twelve *grands prix* awarded in the whole of this class, and this notwithstanding that no award was made to two of our most important exhibitors as they were not manufacturers. Our ornamental glass was admittedly the finest in the Exhibition, and so, I believe, was the stained glass. Our textiles were very good, and the remark was made to me by one of the jurymen that the English goods were fair samples of the makers' ordinary wares, whereas in many other instances goods were shown which never had been, and never would be, produced in the ordinary course of business. In certain cases even some of these were of English manufacture. Here again we suffered because some of the finest exhibits were shown by dealers who had them manufactured to their order, not by the actual makers, and so no awards were made to them. This was especially the case with English silks, and a most exquisite collection of Spitalfields silks went unrewarded.

I think I may say without dispute, that our sporting guns were the best shown, and that our carpets, wall-papers, and other decorative materials, were quite as good as any in the Exhibition. Our scientific apparatus was good though there were few exhibitors. In photography we more than held our own, except in the important class of photo-gravure.

In the machinery section, the largest machine tool was English, so was one of the greatest novelties in textile machinery, and one of the finest collections of looms. Our wood-working machinery was very good, our milling machinery the most complete of any. There was nothing approaching our collection of ship models. Our metallurgical exhibits were first class, some of them unapproached by anything shown.

In the railway section the high character of the British exhibitors astonished everbody, considering how much more difficult it was for English makers to send railway plant across the Channel than it was for Continental builders to employ the direct railway connection which existed from their shops to their spaces in the Exhibition.

In the food products gallery there was nothing of its sort like the English working bakery, in which bread and cakes of every sort were made during the whole period of the Exhibition by a most admirable series of machines, while the whole contents of the English Food Section were good and representative.

We had few agricultural machine exhibitors, but those who exhibited took the lead in the competitive trials, and so proved their high quality, while of the dairy exhibits, I can only say that the award of a *grand prix* to a French dairy instead of to our own was very generally considered to be one of the few instances of distinct—doubtless unconscious—partiality on the part of the juries.

On the whole, I seriously maintain, and I believe it was generally admitted, that the British Section was worthy the high reputation the country has gained in previous exhibitions. That it was so, notwithstanding the adverse circumstances from which its early stages suffered, and the indifference with which the first efforts of its promotors were received, has been a cause of no small gratification to those who have devoted to its service a good deal of hard work, and have had the pleasure of seeing it grow steadily in importance, in value, and in public estimation.

Where so many worked hard as members of committee, as jurors, and in other capacities, for the good of the Section, it seems almost invidious to particularise. Still I should like to mention a very few names, in order to put on record here my own testimony of the value of the help which was rendered. Sir Polydore De Keyser not only came forward at a critical moment and ensured the existence of the British Section, but he supported it throughout with the most lavish generosity. Mr. Chapman, Mr. Donaldson, and Mr. Dredge all spent long periods of time in Paris, devoting themselves to various details of the work, and ready at any moment with advice and help of every sort. Sir Colville Barclay and Mr. Ellicott, both residents in Paris, placed their experience and knowledge unreservedly at the disposal of the committee. Mr. Aylmer, before the Commission was established in Paris, represented them with efficiency and zeal. But especially to the members of the executive staff in general and to Mr. Frank Cundall, the assistant secretary, in particular, are my own personal thanks due. The small number of the staff made the work at times press hard upon us all, and without the devotion and the steady hard work shown by every member of it, we should never have got through as successfully as we did.

Naturally, one of the first suggestions that comes into the mind of a foreigner visiting the French Exhibition is—why should we not have a similar exhibition in our own country? The Americans, with their national promptitude, no sooner had the idea than they decided to act upon it, and we may take it as settled that there is to be a great Exhibition in the States in 1892. Englishmen have asked the same question, but their decision is less promptly made; still the notion has presented itself to many minds, and it is worth consideration. The two principal difficulties are—first, the cost; second, the site. For an Exhibition on the scale, say, of the Colonial and Indian the cost presents no difficulty; it would pay for itself. But after the Exhibition of this year, it is felt that if we are to have a great International Exhibition it must not be inferior to that of Paris. It need not vie with it in buildings perhaps; neither an Eiffel Tower nor a Palais des Machines is absolutely essential; but it must have some distinctive qualities in which it is superior. As I said before, an exhibition on the Paris scale cannot pay. If all the 25,000,000 visitors had paid their franc a-head, the total, £1,000,000, would not have met the expenditure of £1,680,000. There must, therefore, either be a subvention, or the exhibition must be organised on a scale commensurate with the amount of receipts.

Now, I will at once admit that there is no likelihood of the Legislature and the London County Council contributing between them a million sterling towards an exhibition. We have not—collectively even if we have it individually—the same capacity for taking a wide view in such a matter as this as our French friends. Possibly after such definite proof that a big exhibition pays as a speculation, we might be a little less unlikely than before to provide the money, but I doubt it. But on the other hand, are we to admit that we, who invented big exhibitions, and out of them have derived no small profit, are we to admit that we are beaten on our own ground and quietly accept defeat? If this is so, there is no more to be said, except that it indicates a change, and a very unfortunate change, in the national spirit. If the thing is a good thing, and profitable to our commerce and trade, would it not be better to see whether we cannot have our Exhibition too, and a better one than Paris?

Now the great cost of the Paris Exhibition was in the buildings, and I believe this cost was to a large extent unnecessary. Buildings which would serve their purpose every bit as well could be put up for, say, a quarter the price. As we could not rival the monumental splendour of the Paris buildings, we need not try to vie with them at all, but to strive for some other point of superiority. This superiority, I am certain, we could find in the exhibits themselves. We could certainly bring together, say in 1895, a far finer display of the industrial resources of this country than France made last summer in the Champ de Mars. And, surely, we might reasonably expect far stronger support from other countries than she received. We might look for important contributions from Germany. The United States would unquestionably make far greater efforts than they made in Paris. France herself would be no less anxious to show those beyond her borders the development of her industrial resources than she was to make that development evident to her own people and to her visitors. In another six years our own colonies, then, let us hope, bound in a fresh and firmer federation with the mother country, will be ready to repeat the great success of 1886.

With the experience of so many Exhibitions, British and foreign, with abundant time for preparation, with the support alike of the public and of those at the head of the nation, whose support is never wanting to any well-considered scheme for the advantage of the people, there is no reason why we should not have in London—could a site be found—the finest, the most truly international exhibition that the world has yet seen.

But could a site be found? If we are willing to put up with a little inconvenience, a small portion of the inconvenience borne without complaint by the Parisians this year, it certainly might. There are only two open spaces in London in any way suitable. One is Hyde-park, the other is Regent's-park. The northern portion of the Regent's-park, between the Botanical Gardens and the Zoological Gardens, certainly seems to offer the maximum of advantage with the minimum of objection. It is true the frequenters of this portion of the park would be deprived of their playground for a period of some two years, but nobody else would suffer in the least. The neighbourhood would not be affected. It is improbable that the value of house-property, even in the wealthier regions on the south side of the park, would be depreciated to the slightest extent, while the region on the north would be considerably benefited. The means of communication are admirable. A short length of line might put the building in direct communication with the Metropolitan Railway. A temporary railway on the Decauville system might take passengers along the other side of the park, almost to the top of Regent-street. There is space enough and to spare for all the buildings of every part of the Paris Exhibition to be arranged as they would have been arranged had there been room enough, with abundant garden ground between and around them. In no other city in Europe could so good a site be found, and one the use of which would cause so little inconvenience to anybody.

That this idea may be carefully and seriously considered I most earnestly hope, and with this hope I commend it to the consideration of the Society of Arts, the body to which the world owes the conception of the idea of great international exhibitions, and the successful inauguration of the first, perhaps the finest of them all.

DISCUSSION.

Mr. John Leighton said he was probably the only one in the room who had been on the staff of the 1851 Exhibition, and he knew the details of nearly every one which had taken place since. All these great world shows had been progressive, though perhaps not so much so as they might have been made. He did not think the age of exhibitions had passed, and regretted that one was not organized in the Jubilee year, as he advocated at the time. He remarked that in all foreign exhibitions amusement and recreation formed an important feature, whilst in England, education, competition and study, formed the main motive power. He cordially supported the idea of an English exhibition in Regent's-park, in which new features might be introduced, not the least of which would be the collection of animals in the Zoological Gardens.

M. Tripplin wished to thank Mr. Wood for the way in which he had expressed himself respecting his countryman. Mr. Wood had mentioned parts of the English Section as more worthy of notice than others, but he regretted that English watch and clockmaking had been inadvertently overlooked, and he wished to point out the fact that not only the exhibitors in that section had all been rewarded, but that besides they had on an average received each a colloborator's medal, which made the proportion 200 per cent.

Mr. P. L. Simmonds said he had seen some service in connection with previous exhibitions, from 1862 downwards, both at home and abroad. He was afraid people were getting rather tired of them, especially as they had not taken the decennial character at first anticipated, but occurred nearly every year somewhere or other, and they did not mark the stages of progress so plainly as was originally intended by the Prince Consort. He could not agree that England was well represented in Paris, several important industries not being represented at all, and thus we did not appear to have made so much progress as France. In 1867 and 1878 the ten years' progress was shown in the exhibition catalogues, but this was not done this year, which was much to be regretted, both from the educational and industrial point of view. The jury question had always given trouble, as he knew from personal experience. Large manufacturers did not care to compete with smaller ones, and the question of how the jurors should be appointed—by the exhibition or by the State—was always a difficult question. Men of position would not devote the necessary time to the work without some reward. The French jurors, most of them received the Legion of Honour, but the English jurors were asked to act without this incentive. Of course, the economical question was an important one, and medals cost money, but he thought the exhibitors would be satisfied with the diplomas. Outdoor amusements must be provided to attract visitors, as had been shown at the Colonial Exhibition at South Kensington, and this question would have to be considered in any future exhibition in Regent's-park or elsewhere. He thought that exhibitors who had any cause for dissatisfaction with the awards should have an opportunity of appealing to a superior jury.

Dr. BLACK said the late Exhibition, at which he had spent a great deal of time, was the most splendid example he had ever seen, but nevertheless he was better pleased with that of 1878, which was less crowded, and the distances to be traversed were not so great. The Eiffel Tower was the great attraction to everyone, and was the last thing imprinted on the eye of the visitor when he left Paris. The finest view of the Exhibition, however, was obtained from the Trocadéro Tower. He did not think a similar tower would be so successful in England, owing to the different condition of the atmosphere, which would prevent anything being seen.

Mr. T. W. SMITH (Caslon's Type Foundry), agreed entirely with the suggestion of doing away with awards. His conviction was that the best manufacturers of a country, having attained a world-wide reputation, shrank from subjecting themselves to competition with those of inferior grade. Many of the best manufacturers of England were not represented at the Paris Exhibition, but in future, if no awards were made, better results might be achieved. A jury should be a chosen committee of men connected with the business with which they had to deal, but it was almost impossible to find men of the requisite eminence and skill who would be perfectly independent and unbiassed.

Mr. FRANCIS COBB said Mr. Wood had given a long and very interesting paper, in which, with great ingenuity, he had contrived to leave himself and what he had done altogether out of the account, but, in fact, he had been all through one of the most prominent features of the work done in Paris. The Government having taken up a peculiar position in this matter, when Sir P. Cunliffe Owen was applied to, being an official, he was unable to act, but he advised the committee, if they could get the sanction of the Society of Arts, to secure the services of Mr. Trueman Wood. The Council had some very serious discussions as to whether they would be justified in allowing their Secretary to be absent for so long as would be necessary, but he thought they would all rejoice that the Council had the courage to take the step they did, and allow Mr. Wood to act as secretary to the Commission. He heartily congratulated him on this paper, and he hoped it would be recognised that the Society was as willing now as ever to take a part in any good work of this kind.

Mr. ADDIS (Sheffield) said he gained a prize in 1851 for carving tools, and again in 1862, when the competition was much more keen, he had also gained a prize medal; but he felt he had reason to complain of having been overlooked on the present occasion. Those whom he had taught were leaving him and competing with him.

Mr. LEE BAPTY agreed with almost all the suggestions in the paper, particularly with regard to juries. In his opinion it was impossible to obtain a jury which should be both competent and impartial. If a man had any knowledge at all of the subject he was to adjudicate upon, he would have practically made up his mind before he went into the room. He had seen remarkable instances of that. Unfortunately, it seemed impossible to get exhibitors to come forward without some strong inducement in the shape of awards. He was sorry to say that in the case of the Edinburgh Exhibition next year the council had been obliged to consent to give awards in all sections in order to comply with the wishes of the commissioners of the various foreign countries. As to holding an exhibition in London, he thought that all Englishmen who had been to Paris must feel a desire that we should be able to beat that Exhibition. It would take a deal of beating, but if such a site as had been suggested could be obtained, and he did not see why it should not, no doubt an exhibition could be put before the world which would vie even with the one just closed. It must of course come after the American one in 1892, and if 1895 were found open, it would allow of ample preparations being made.

Mr. THOMAS LOUGH did not wish to introduce a note of discord into the harmony of the meeting, but he must say that some exhibitors did not take the same eulogistic view of the action of the British Commission as was put forth in the paper. He had been especially acquainted with the Indian Pavilion, having the representation of the Indian Tea District Association entrusted to him, and having spent a great deal of time there, and he must say that the gentlemen connected with that important industry were a little dissatisfied. It was stated in the paper that it was suggested that £2,000 might be raised by shops, but the fact was, when no one who took an interest in the proposed pavilion from an artistic point of view would put down a shilling, the Indian tea importers signed a guarantee for £3,000, and made themselves responsible for £1,900, in order that the Indian Pavilion might be erected. They took the first and most essential step, their plans were realised, and the shops let readily. Most of these guarantors were rather dissatisfied with the way in which they were treated by the British Commission; it was not correct to say that they had any special favour shown them with regard to sales, for that was done all over the Exhibition. Facilities of various kinds were refused, and the loss they made was much greater than it need have been. At the same time, he wished to acknowledge fully the great courtesy and attention they always received from Mr. Wood, and he knew it was always difficult to satisfy everyone.

Mr. England, as Vice-President of the jury for Class 12, thought some previous speakers had hardly done justice to the jurors, many of whom he came in contact with during his stay of two months. The anxiety displayed by these gentlemen to do their duty to everyone was most admirable. In his own class all the French gentlemen were thoroughly conversant with the exhibits, everyone of which was thoroughly examined, not only once but two or three times. There was seldom a meeting at which every juror was not present; and he was satisfied that the constant attention of Mr. Wood greatly conduced to the success which was attained.

Baron de Bush said it had been suggested that some of our most important industries were not represented, and he ventured to say that the one cause of this was that the British manufacturers were not approached in the proper manner. It was the exhibitors who made an exhibition, and when the committee was formed at the Mansion-house, if the heads or representatives of each of the principal industries of the country had been appealed to and induced to exhibit, the minor ones would have followed suit. If another exhibition were to be held in London, he would suggest that a committee of probable exhibitors should be formed, who might meet and discuss the various points which would affect their interests. There was a meeting of the London Chamber of Commerce, at which a resolution was passed that it was advisable to support the Paris Exhibition, but it had little or no value, because it was generally understood that a committee would be formed either by the Government or the Society of Arts, or the Chamber of Commerce. The exhibitors paid the piper, and he thought they should be allowed to call the tune.

Mr. Atkinson desired to thank Mr. Wood for the many services he had rendered him and other exhibitors. Whenever he went to the British office he generally found a string of people waiting to see the secretary, and in a very short time he gave them what assistance he could. Mr. Frank Cundall, Mr. Joseph Cundall, and the different superintendents also helped in every possible way to make the British and Colonial Sections a success. He had to do with the mining department, being in charge of the De Beers Mining Company's exhibit, and with regard to the juries, he might say that they paid three visits, and on one occasion stayed three hours. The conclusion he came to was that exhibitions always paid. At the Colonial Exhibition he met people who said they were doing nothing; at Glasgow he met the same men, who said there was nothing doing there, it was the Colonial Exhibition where business was done, and at Paris again the same people said it was not so good as at Glasgow, that the French people did not do business at all. There were always some who were satisfied, and others who would always grumble. The best test was the amount of money which was spent in Paris. At the Colonial Exhibition he had to do with the diamonds, and during its progress prices went up so much, partly on account of the Exhibition, that when they came out they fetched 25 per cent. more than they would if sold at the beginning. In Paris there was nearly a million sterling value in diamonds, and whereas they were worth 20s. a carat at the beginning, at the close, owing to the amalgamation of the companies, none of them were sold under 40s. He knew one gentleman who made a profit of £7,000 on the sale of one small parcel.

Mr. Trueman Wood, in reply, said he was glad to see a fair consensus of opinion about the jury awards, especially when it was shared by one of so much experience as Mr. Lee Bapty. He was convinced that the time for them was gone by; they could not be distributed with absolute fairness, and therefore it was much better to give none at all. It was, of course, more difficult to get people to work for nothing than when they were paid, but he was proud to be able to say that as regards the British jurors they got a fairly representative body of gentlemen who were willing to spend a good deal of their time on a very thankless task, without any pay at all. One great difficulty was the large extent of the classes. The British Commission could only have one or two representatives on a large and varied class, as, for instance, in metallurgy, on which there were two thoroughly competent and efficient jurors, bnt he was afraid neither of them knew much about pins, needles, and fish-hooks which were included in the class. In reference to Mr. Lough's remarks, he might say that there were special difficulties in connection with the Indian Section, the details of which would not interest the meeting, but he would ask Mr. Lough and others to believe that those deficiencies were caused mainly by the rules of the administration, and were not such as the British Commission could overcome. There were difficulties also with regard to the jurors, and there were cases of absolute injustice, which it was impossible to get rectified, but he believed they were very few. It was much to be regretted that they should have occurred at all; and that was a reason for abolishing the system. In reply to Baron de Bush, he would say that the would-be exhibitors had about two years in which they might have organised themselves, but they did nothing, except complain occasionally that no organisation was forthcoming by which Great Britain could be represented. When it was almost too late for any organisation to deal with, M. Berger came over and went round doing all he could to induce some one to take up the formation of a committee, until at last Sir Polydore de Keyser, actuated by purely patriotic motives, said he would undertake, if the Government did not actually object, to form the best committee he could. On that committee there was as good a representation as could be got together of the various most important industries, and if any one could see the correspondence, he would not say that the manufacturers of England had not been applied to or consulted. He could only thank the meeting for the kind way in which they had received the paper. It had been a great satisfaction to him to be connected with so great an undertaking, and also to have the opportunity that evening of rendering an account of his work to that body to whom his first allegiance was due, and to find his report received in so kindly a spirit by the Society.

The CHAIRMAN said Mr. Wood had worthily crowned his successful labours in connection with the Exhibition by this admirable paper, full of information, judicious criticism, and valuable suggestions. Those who were connected in any way with the efforts to establish a British Section well knew the difficulties that had to be encountered, and how much the country was indebted, in the first place to Sir Polydore de Keyser, for placing himself at the head of a few gentlemen who were determined that this country should not remain unrepresented, and also to Mr. Wood for the very valuable advice which he offered at the outset, and eventually for his indefatigable labours in arranging the British Section. They might have wished that it had been more complete and more thoroughly representative of British industries, but they could not help feeling proud of the fact that men without the slightest assistance from the Government were able to carry through to so successful an issue what proved to be not only an interesting but an important portion of the French Exhibition. The discussion had been interesting, and the questions discussed called for very serious reflections in connection with future exhibitions, for future exhibitions no doubt there would be. They were continually saying they had had enough, but he ventured to think that this French Exhibition taught a lesson to the effect that such displays were fruitful of most important results to the commerce and industries of the countries which carried them out. So far as foreign countries were concerned, this one had produced most important results already, and he could not help feeling that in the great competition between nations, whenever an effort of this kind was made, unless other nations followed with similar efforts they would fall to the rear. So that, however they might grumble at being forced into it, they were bound to take part, and it would be the duty of those who had the interests of the country at heart to consider how we might worthily compete with our neighbours in matters of industry, commerce, and technical education. In conclusion, he proposed a hearty vote of thanks to Mr. Wood for his interesting paper.

The vote having been passed,

Mr. TRUEMAN WOOD, in reply, said he should like to carry a message of sympathy from the meeting to Sir P. Cunliffe-Owen, who had only been prevented by a sharp attack of bronchial asthma from presiding on that occasion. He had also to thank Sir Frederick Abel for coming forward at very short notice to take his place.

Miscellaneous.

THE WORLD'S MEAT CONSUMPTION, PRODUCTION, AND TRADE.

The average consumption of meat in the world has increased, but on the other hand, the world's commerce in meat has declined. Germany's imports of meat declined from £18,890,000, in 1878, to £14,740,000, in 1887, while the exports declined from £17,660,000 to £6,780,000. In France, between 1879 and 1887, imports diminished from £16,460,000 to £10,782,000, while exports increased from £7,190,000 to £10,520,000. In England, where exports of meat are insignificant, the imports decreased from £48,000,000 in 1880, to £43,000,000 in 1887. On the other hand, the British colonies exported largely; for example, from Canada the exports increased from £886,000 in 1879, to £6,000,000 in 1887. Australia exported also large amounts. In Austria-Hungary imports diminished from £2,190,000 in 1879, to £1,600,000 in 1887, while exports increased from £4,150,000 to £6,780,000. In the United States imports increased from £1,420,000, in 1879, to £3,330,000, in 1887, while exports decreased from £25,760,000 to £22,520,000. Importations into Belgium decreased from £3,280,000 in 1879, to £2,080,000 in 1887; in Italy, from £4,240,000 to £2,800,000; in Russia, from £3,666,000 to £2,080,000. By adding the above figures it is found that the entire imports of meat into the countries specified have diminished from £98,194,000 to £80,624,000, while the entire exports decreased from

£55,636,000 to £48,940,000. In 1875, Germany possessed 24,400,000 neat cattle (four small cattle, such as sheep, hogs, and goats, being reckoned as one), in 1883, only 23,500,000. Between 1881 and 1887 there was in France an increase from 19,700,000 to 20,750,000; in Great Britain, from 17,800,000 to 18,600,000; while in Austria-Hungary the figures remained the same. The increase in population in these countries during this time was as follows:—In Germany, 3,500,000; France, 480,000; Great Britain, about 3,000,000; and Austria-Hungary, 2,000,000. The ratio in France on account of the small increase of population is most favourable. This country therefore could increase its exports, says the United States Commercial Agent. In Germany the ratio is very bad, the number of neat cattle having diminished 900,000 head, and the population having increased 3,500,000. It is most remarkable in the case of the United States, where imports increased 130 per cent., and exports diminished 12½ per cent., although the number of neat cattle increased from 56,600,000 head in 1880, to 71,200,000 in 1888, and the population increased only from 50,500,000 to 62,000,000.

Notes on Books.

Paris Exhibition Artisans' Reports. London: C. F. Roworth. 1889.

The work carried out by the Society of Arts in 1867 and 1878 of sending over to the Paris Exhibitions of those years a body of selected artisans to report, was for the present year's Exhibition taken up by a special committee under the presidency of the late Lord Mayor, Sir James Whitehead. By this committee 75 delegates were sent to Paris, the reports of all of whom are printed. The selection was purposely limited to metropolitan trades, it being left to the provincial centres of industry to follow the example of the metropolis if they saw fit. In some cases employers of labour in the provinces did send some of their men over, but there were not many in addition to those sent by the Mansion House Committee. The reports have been edited by Mr. C. J. Drummond, but not very much alteration appears to have been made in them. Most of the London industries—all the important ones apparently—are included; the building trades, bricklaying, carpentering, plumbing, &c.; the decorative industries, carving in wood and stone, die-sinking, goldsmiths' work, paper staining, engineering, glass and pottery, bookbinding, metal working, printing, type-founding, and stereotyping, with many others. The promptitude with which the book has been issued adds much to its interest and value.

Obituary.

H. R. Newton, F.R.I.B.A.—Mr. Harry Robert Newton, of Thamesyde, Weybridge, a member of the Society of Arts since 1878, died very suddenly of heart disease on the 14th November. Mr. Newton was the son of the well-known miniature painter, Sir William John Newton (who died 1869), and he was a collateral descendant of Sir Isaac Newton. Mr. Newton acted as architect of the Society when some considerable alterations were made in the reading-room, &c., in 1863. He was particularly interested in sanitary matters, and in the present year he delivered an address at Worcester on "The Errors of Exposing Sewage to Light and Air."

General Notes.

Intermediate Technical Education.—The National Association for the Promotion of Technical and Secondary Education have published a manual to the Intermediate Education (Wales) Act and the Technical Instruction Act. It has been prepared by Mr. Thomas Ellis, M.P. for Merioneth, and Mr. Ellis Griffith, Barrister-at-Law. The book bears special reference to Wales, but it also contains a good deal of general information, including suggestions from the educational systems of other countries, besides the Acts themselves, with notes.

Technical Education in England and Wales.—The National Association for the Promotion of Technical and Secondary Education has published a report on existing facilities for technical and scientific instruction in England and Wales, by Messrs. Arthur Acland and H. Llewellyn Smith. The object of the report is to provide in a convenient form information as to what is being done at the present time, with an account of the Science and Art Department and of the City and Guilds Institute, of the principal technical institutions in the country, and of the means existing for technical education in other educational institutions. It is illustrated by four maps, showing the local distribution of science classes, art classes, technical classes, and drawing in elementary schools.

Mineral Wealth of Salvador.—The South American State of San Salvador is said to contain practically inexhaustible mineral wealth, chiefly in the departments of Morazan, Union, and San Miguel. There are now in active working several quarries of building stone and plaster of Paris, a marble quarry, two lead and silver mines, one lead and tin mine, three lead mines, nine iron mines, one of mercury and antimony, two of gold, a hundred of gold and silver, seven of copper, five of copper and silver, and four collieries, while there are also numerous deposits of lignite. The Titiquapa coal, of 1·57 specific gravity, contains only $10\frac{1}{2}$ per cent. of ash Mines are granted in concession by the Government, or by previously constituted proprietors, and concessions are perpetual and transferable; but concessionaires must have discovered the mineral they wish to work, and must become possessors of the surface. In order to develop the mineral wealth of the country exceptional facilities are accorded by the Government to those engaged in mining operations; and they are exempted from military service, while also. enjoying immunity from several taxes.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

DECEMBER 18.—SIR ROBERT RAWLINSON, K.C.B., "London Sewage." Professor SIR HENRY E. ROSCOE, F.R.S., M.P., in the chair.

CANTOR LECTURES.

Courses of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

WILLIAM JAGO, F.C.S., F.I.C., Modern Developments of Bread Making." Four Lectures.

LECTURE IV.—DECEMBER 16.—*Modern Ovens —Recently Invented Bread-making Processes.*—Old-type ovens.—Internally-heated ovens.—Requirements in an oven.—Furnace outside the bakery.—Should be economical in fuel and perfectly smokeless.—Should retain its heat and also the steam produced by evaporation from the bread during baking.—Continuous baking.—Effect of materials used in oven-building.—Preference of many bakers for old-type ovens.—Modern inventions.—Various types of modern ovens.—Recently invented bread-making processes.—Utilisation of germ.—Its objectionable qualities forcibly described by Graham.—New process of germ treatment.—Bread from germ flour.—Excessive diastasic properties of flour in former times.—Alum and other bodies used to prevent this action.—Introduction of diastase during the process of bread-making.—Valuation of bread.—Problem of securing effective control over supply of bread and flour to soldiers' barracks, workhouses, and other public institutions.—Conclusion.

JUVENILE LECTURES.

Two Juvenile Lectures, on "The Story of a Flame," will be given by Professor VIVIAN B. LEWES, on Wednesday evenings, January 1 and 8, 1890, at Seven o'clock.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, DEC. 16...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. William Jago, "Modern Developments of Bread-making." (Lecture IV.)

East Coast Institute of Engineers and Shipbuilders, Newcastle-on-Tyne, 7.35 p.m. 1. Mr. J. C. Spence, "The Strength of Boilers." 2. Mr. Charles B. Casebourne, "The Construction of Marine Boilers with a view to the Use of Higher Pressure."

British Architects, 9, Conduit-street, W., 8 p.m.

Medical, 11, Chandos-street, W., $8\frac{1}{2}$ p.m.

Asiatic, 22, Albemarle-street, W., 4 p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. Henry Wallis, "Lustre Decorations in Ceramic Art."

TUESDAY, DEC. 17...Civil Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on Professor Osborne Reynolds's paper on "Triple-Expansion Engines and Engine Trials."

Statistical, School of Mines, Jermyn-street, S.W., $7\frac{3}{4}$ p.m.

Pathological, 20, Hanover-square, W., $8\frac{1}{2}$ p.m.

WEDNESDAY, DEC. 18...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Sir Robert Rawlinson, "London Sewage."

Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Mr. W. H. Dines, "Report of the Wind Force Committee on the Factor of the Kew Pattern Robinson Anemometer." 2. Mr. W. H. Dines, "Testing Anemometers." 3. Mr. G. J. Symons, "The Rainfall of the Riviera." 4. Mr. Edward Mawley, "Report on the Phenological Observations for 1889."

Geological, Burlington-house, W., 8 p.m. 1. Mr. E. Wethered, "The Occurrence of the Genus *Girvanella*, and remarks on Oolitic Structure." 2. Prof. Joseph Prestwich, "The Relation of the Westleton Beds or 'Pebbly Sands' of Suffolk to those of Norfolk, and on their extension inland, with some observations on the Period of the final Elevation and Denudation of the Weald and of the Thames Valley."—Part II.

Patent Agents, 19, Southampton-buildings, W.C., 7 p.m. 1. Discussion of the Vice-President's Report of his attendance at the Paris Congress. 2. Mr. E. Carpmael, "American Interferences." 3. Mr. G. G. M. Hardingham, "Working French Patents."

Civil and Mechanical Engineers, Westminster Palace Hotel, S.W., 7 p.m. Mr. R. Bolton, "Percussive Rock-drilling Machinery."

THURSDAY, DEC. 19...Royal, Burlington-house, W., $4\frac{1}{2}$ p.m.

Antiquaries, Burlington-house, W., $8\frac{1}{2}$ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Rev. John T. Gulick, "Intensive Segregation and Divergent Evolution in Land Mollusca of Oahu." 2. Mr. T. Johnson, "Dictyopteris, with remarks on the Systematic Position of the Dictyotaceæ."

Chemical, Burlington-house, W., 8 p.m. Professor Thorpe and Mr. H. H. Robinson, "Frangulin."

London Institution, Finsbury-circus, E.C., 6 p.m. Prof. Silvanus P. Thompson, "The Optical Properties of Gems and Precious Stones."

Historical, 11, Chandos-street, W., $8\frac{1}{2}$ p.m.

Numismatic, 4, St. Martin's-place, W.C., 7 p.m.

Journal of the Society of Arts.

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FRIDAY, DECEMBER 20, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

JUVENILE LECTURES.

The usual short course of lectures adapted for a juvenile audience will be given on Wednesday evenings, January 1 and 8, by Professor Vivian B. Lewes, on "The Story of a Flame."

The lectures will commence at seven o'clock. A sufficient number of tickets to fill the room will be issued to members in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each member is entitled to a ticket admitting two children and an adult. Tickets are now in course of distribution, and members requiring them should apply at once.

CANTOR LECTURES.

The fourth and concluding lecture of the course on "Modern Developments of Bread-making," was delivered on Monday evening, 16th inst., by Mr. William Jago, F.C.S., who dealt more particularly with the subjects of modern ovens and recently invented bread-making processes.

A vote of thanks to the lecturer was passed on the motion of the Chairman.

The first lecture will be printed in the next number of the *Journal*.

Proceedings of the Society.

FIFTH ORDINARY MEETING.

Wednesday, December 18, 1889; Sir Henry E. Roscoe, F.R.S., M.P., in the chair.

The following candidates were proposed for election as members of the Society:—

Bull, J. G. Cuthbertson, Bloomsbury-mansion, Hart-street, W.C.

Copperthwaite, Harold, York.

Money, Robert J., care of T. W. How, 35A, Great George-street, S.W., and Puerto Cabello, Venezuela, South America.

Scott, Ronald A., The Elms, Acton-hill, W.

The following candidates were balloted for and duly elected members of the Society:—

Bromley, Walter Brandreth, Crofton-house, Lampton-road, Hounslow.

Galloway, Earl of, K.T., Cumloden, Newton Stewart, N.B.

Hobbes, Robert George, Livingstone-house, 374, Wandsworth-road, S.W.

Lake, William Robert, 45, Southampton-buildings, Chancery-lane, W.C.

McBean, Alexander, 2. Devonshire-terrace, Portland place, W.

Portman, Viscount, 22, Portman-square, W.

Raven, Henry Baldwin, 139, Temple-chambers, Whitefriars, E.C.

Sangster, Arthur, 12, College-crescent, South Hampstead, N.W.

Stephens, T., 1, Cuba-street, Millwall, E.

Symes, James Page, 74, Lewisham High-road, S.E.

Thorpe, Harry, 59, Theobald's-road, W.C.

The Chairman said:—It gives me much pleasure to take the chair on this occasion, when a veteran in sanitary knowledge, Sir Robert Rawlinson, is about to give us his views on a subject of such vast importance to the metropolis as that of "London Sewage," and the purification of the Thames. It is a matter in which I myself have taken a considerable amount of interest, for, as the members present will know, I was consulted by the late Metropolitan Board of Works on the subject of the deodorisation of the effluent, and I presented to them several reports on that subject. In addition to this, I made a statement expressing my views on the whole question of the treatment of the metropolitan sewage, which has been laid before the members of the Main Drainage Committee in the form of a pamphlet. In the first of my reports to the Metropolitan Board I ventured to remark that "looking at the broad question of the permanent disposal of the metropolitan sewage, and believing that the use of deodorants ought to be regarded only as a temporary expedient, I feel convinced that sooner or later the recommendations of Lord Bramwell's Commission will have to be adopted, and that the sewage, whether previously clarified or not, must either be filtered through land or discharged into the estuary at a point not higher than the sea reach. The growth of the metropolis during the quarter of a century which has elapsed since the adoption of the present main drainage and outfall system has been so enormous, that arrangements which worked satisfactorily up to some years ago are found to be inadequate, and will of course become more so as time goes on." In the pamphlet above referred to I pointed out, from a chemical point of view, that the present process of precipitation did not cause any improvement in the quality of the effluent, and moreover, that the arrangements made for the separation of the sludge from the effluent at Barking and Crossness were in my opinion, from a scientific point of view, based on false principles, and the consequent barging of the sludge out to sea a mistake. I also suggested that an engineer and chemist be appointed to report to that committee on the whole question of the treatment and disposal of the sewage of the metropolis, as a basis for future action. It is interesting to find that the County Council only yesterday endorsed these views, by refusing to adopt the recommendation of their Main Drainage Committee to obtain tenders for the construction of two more steamers, at a cost of £20,000 each, for carrying the sludge out to sea, and by instructing that committee to secure the services of an eminent civil engineer to join the engineer of the Council in a thorough examination of the whole sewage system. It is also satisfactory to find that the Main Drainage Committee agree with the Royal Commissioners of 1884 that it is neither necessary nor justifiable to discharge the sewage of the metropolis into any part of the Thames from the Nore upwards, and are convinced that the probable alternative to the scheme of the Metropolitan Board, viz., precipitation in underground reservoirs, separation of effluent from sludge, and the carrying out of the latter to sea, would be in the conveyance of the sewage to the sea upon the Essex shore by some such plan as that sanctioned by Parliament in the Act of 1865. The Main Drainage Committee further add that, should separation of sludge from effluent be carried out in the future, such a separation must be conducted at Barking and Crossness. To this I should wish to add my opinion, that should precipitation not be deemed advisable, the reservoirs now constructed might still be used for storage during the flood tide, when it might be undesirable to allow the sewage to flow out even at such a distance from the metropolis. I understand that Sir Robert Rawlinson does not propose to consider the question of the chemical treatment of the sewage, and I therefore venture to make these few remarks as indicating my views of this part of the subject. I have now great pleasure in calling upon Sir Robert Rawlinson to give us his paper.

The paper read was—

LONDON SEWERAGE AND SEWAGE.

By Sir Robert Rawlinson, K.C.B.,
Vice-President Inst.C.E.

The River Thames.

As it must be of interest to the ratepayers generally to know something of the beautiful river which flows through London, I venture to give some details as abstracted from an official report.

The area of the basin of the Thames, according to the Ordnance Survey, is about 5,162 square miles, and from Trewsbury Mead to the estuary, in its greatest length, it is 201 miles. There are eleven tributaries. Upon the north side—the Churn, Coln, Windrush, Evenlode, Cherwell, Thame, Colne, Yedding, Brent, Lea, and Roding; on the south side—the Ray, Cole, Ock, Kennet, Loddon, Wey, Mole, Hog's-Mill, Wandle, Ravensbourne, and Darent. In its course it flows through or by the counties of Wilts, Gloucester, Oxford, Berks, Bucks, Middlesex, Surrey, Kent, and Essex.

The river in its course to the sea flows past Oxford, Royal Windsor, Reading, and Imperial London, and (geologically) over beds of oolite, chalk, and London clay, covered mostly with water-washed gravel, which, in some cases, extend over wide areas on both sides of the main channel, the gravelly sub-areas acting as natural filter-beds, and giving the bright and clean appearance to the water, so that it has deservedly earned the poet's name, "The Silvery Thames." There are no swamps or marshes of any extent on the Thames, but in parts steep banks; with, in other parts, bordering rich meadows. The dry weather flow is, consequently, for the most part, spring or filtered water. When the river is in flood, considerable areas of meadow land on both sides are partially submerged, and the water is then, for a short time, turbid, but not to any extent which is injurious; on the contrary, such floods may be accounted as beneficial; the detritus from the clay and chalk acting as disinfectants, so that floods tend to purify rather than to pollute the water. and the increased volume and more rapid flow flushes the river. The main channel of the river is said to have been navigable "time out of mind," having been designated "a common highway." Jurisdiction over the river is now exercised by a body of Conservators, Admiral Sir Frederick W. E. Nicolson, Bart., C.B., being chairman.

The River Lea is a northern tributary of the

River Thames, having a watershed area of about 500 square miles; or, 320,000 statute acres, being about one-tenth that of the area of the main river. Its rise is in Leegrave Marsh, from chalk springs situate in the county of Bedford. The river is tidal from the Thames to Lea Bridge, a distance of about five miles, and above this point it is navigable for barges to Hertford. The Stort joins the Lee at Feilds Weir, and is navigable for a distance of 13½ miles. These details are given, as the water from the River Lea, by the New River, supplies so large a portion of of the north and east of London, and it is also involved in sewage pollution, similar to the Thames.

I may also say here that the purification of the area of the River Lea, and of the towns and villages draining towards it, should be included in the purification works for the metropolis. London "over the border," which now, with its railways, docks, engineering works, and warehouses, has become what in itself, if standing separate, would be a third-rate town of great importance, and ought not any longer to be treated by the Metropolis as an outcast foundling. West Ham, Silvertown, Barking, and the adjacent populations, can well afford to pay their equitable share of municipal rating, if they receive in future the consideration which was denied them in the past by the old Metropolitan Board.

London City.

London had of course a beginning, but of that period we have no reliable history. During the Roman occupation it was a small walled city, having an area of little more than one square mile, the Fleet river flowing by it to the Thames. We have not much to do with the city from the Roman period down to the beginning of this century, as sewering, draining, and scavenging had only been prosecuted in the rudest form, such as we may see or read about as existing in the cities of the old world. We have to do with modern London, dating back to 1801. At about this time water-closets appear to have been introduced, and in the city main-sewers began to be extended.

The main-sewers then built were generally flat-bottomed, vertical-sided, and arched. House-drains were of brick, varying from one foot to three feet in diameter. The first formed main-sewers were, for the most part, without ventilation, and the house-drains were untrapped.

As previously stated, water-closets were being introduced, the excreta being washed to the large unventilated sewers, the results being, what we do not now wonder at, namely, outbreaks of fever in excess. To prevent this, Parliament inserted clauses in an Act forbidding house-drains (where water-closets were in use) communicating with the sewers, and these clauses were inserted into towns' improvement Acts in general use throughout the country. The results springing from these clauses could hardly have been anticipated They were, however, most fatal, the defects remaining in many large London houses, and generally in other large houses throughout the country. As Engineer Inspector I had to find out and remedy many such cases.

It is now hardly possible to conceive that the remedy would have been cesspools within the basements of houses, but such was the case. A use of the public sewers having been forbidden, "dry-wells," "dumb-wells," or "cesspools," as they were variously called, were constructed upon the premises to receive the contents of the water-closets. Where the subsoil was porous, it was hoped the fluids would filter away; where it was clay or retentive strata, and the so-called "dumb wells" were filled to overflowing, small drain channels were, in some cases, surreptitiously made to the sewers; or, the cesspool contents had to be pumped to the sewers, which was, of course, illegal; but like other clauses of a similar kind, this pardonable breach of law went on unobserved. To indicate how extraordinarily general this evil became, I may state that in Windsor Castle there were some 53 "dumb-wells," *alias* "cesspools," sunk in various parts of the basement, which is chalk. This is a porous strata, and for a time absorbent, but the wells, in 1849, were full and overflowing.*

The first Public Health Act was established in the autumn of 1848, and was inaugurated at Gwydyr-house, Whitehall. A little after Christmas in that year, the housekeeper came to my room to ask me to come downstairs and see the condition the basement was in. I, of course, went down, and found the basement flooded with sewage. It may be noted, that the building previously having been occupied by comparatively few people, was then (1848) filled with many people, clerks and inspectors of the new Board, and, consequently, the water-closets had been more used. On being asked by the office-keeper what was to be done, I said to him, "Wait until I go and consult the Board now sitting," which then consisted of Lord Morpeth, Lord Ashley, and Mr. Edwin Chadwick. When I went in, Lord Morpeth said, "Well, Rawlinson, what is it?" I said, "The basement is flooded with very foul fluid, and I suggest that the Office of Works be requested to cause examination to be made." He said at once, "Let that be done." I sent over to the Office of Works, whose workmen came; and, on examination, we found within the basement of the Board of Health offices three cesspools, full and overflowing with putrid sewage. Ultimately, on further examination, six others were found, making nine in all. Only think of a Board of Health sitting over nine cesspools! Since then I have seen the basements of large houses opened up in various parts of London, in the country, and in Dublin, all similarly tainted, and I am satisfied that there are very many large houses in a similar condition now, both in London and in the country.

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* I may say, however, that under the late John Turnbull, clerk of works at the Castle, the foul cesspits were abolished and filled up with quicklime concrete, and he had the entire premises put into the best and most approved sanitary condition before 1851.

This is a brief but true statement of the condition of London and other large towns, as regards the law of sewers, drains, and cesspools, up to the passing of the Public Health Act, 1848, and the Main Drainage Act of 1855. From these dates cesspools have been abolished by tens of thousands, the putrid contents having been poured into the London sewers, and from thence flowing direct into the River Thames, causing intense pollution. It was during this process that the Thames became so extra foul and offensive, helping to bring in the law establishing the Metropolitan Board, and arming it with full powers to inaugurate main-drainage, so as once and for all to purify the river by freeing it from corrupt crude sewage.

Previous to 1848, and up to 1855, London and the surrounding districts had no proper system of local government, each parish having its own methods of parochial administration; London then, outside the City, having no orderly and responsible form of government.

Within the metropolitan limits, local administration of some sort was carried on by no fewer than 300 different bodies, deriving power from about 250 different local Acts, the number of Commissioners being computed to exceed 15,000.

In 1847, there were, for London, eight separate local Commissions of Sewers, each having jurisdiction over the districts under its charge. These districts were:—The City of London, Westminster and part of Middlesex, Holborn and Finsbury, The Tower Hamlets, Poplar and Blackwall, Greenwich, Surrey and Kent; each Board employing its own engineer, who devised, set out, and executed sewers and sewerage-works according to his own notions as to capacity or gradient. When these separate Commissions were repealed, and the then new Metropolitan Board was established, it was found that some of the sewers were not true, either in subsectional form, in line, or in gradient.

About this time two of the surveyors—the late John Roe, of the Holborn and Finsbury Vestry, and Mr. John Phillips, of the Westminster Commission of Sewers—distinguished themselves by introducing improvements which, as regards the cross-sectional forms of sewers, have not been superseded. Under these men a new order of things in main-sewering was commenced. Mr. John Roe obtained a retiring pension, and is dead; Mr. John Phillips retired without a pension, is alive, is not in affluent circumstances, and ought to have a pension.

THE FIRST BOARD OF HEALTH.

This Board, established in the autumn of 1848, lived a short life, did some good work, but was abolished in 1854.

LONDON SEWERS. — THE METROPOLITAN BOARD ESTABLISHED 1855.

I must preface my remarks on the main-sewers of London by some general observations as to the first principles to be observed in town-sewering. If the site upon which London has been built had been carefully examined (I have no doubt but that it was in part, though not so fully as might have been done), it would have been found that the surface-gradients to the river, north and south, presented valley-lines which required special provisions, so as to remove as much as possible of the water falling on the surface, as also to remove spring and other subsoil-water from the sewers to the river. This was not fully done, and the penalty has had to be paid in extra sewers of relief, costing upwards of £700,000 and other large extras. In forming the Thames Embankment from Westminster to Blackfriars, the underground railway has, in some degree, been allowed to usurp the site, and so cripple the low-level intercepting sewer in its dimensions and capacity, to the great detriment of the main-sewerage system along this line, and this has made it necessary to provide large storm overflows, causing pollution of the Thames from this small intercepting sewer. It ought to have been self-evident to the Metropolitan Board that the Thames Embankment, from Westminster to Blackfriars, was primarily made to facilitate the main sewering system of London rather than the works of a private company.

Before deciding as to the position, direction, and dimensions of the main intercepting-sewers, there were numerous experiments and calculations made as to areas, gradients, falls of rain, the waste by evaporation, and the flow of water from the area under consideration. I readily admit that this question involves so much of uncertainty in that which cannot, in all respects, be foreseen that some errors as to dimensions of sewers may be condoned, and some inconvenience, by surface and sewer flooding, be put up with. As I do not know a great town, or indeed a great railway in England, or a river area of any importance which is not now and then flooded so as to cause inconconvenience and damage, Londoners must, I fear, submit to this common inconvenience now and then, and most unquestionably must put up with Thames pollution through London from the main-sewers storm-sewage overflows. The only comfort is in the fact that these floodings may not take place more than on 20 or 30 days in any year, and then in wet seasons, when the river is in flood.*

ESTABLISHMENT OF THE METROPOLITAN BOARD.

In 1853, a Royal Commission was appointed to inquire into the state of the Corporation of the City of London. These Commissioners did not approve of making the City supreme in jurisdiction over the entire of London, but recommended a division into municipal districts.

In 1855 an Act was passed, constituting the Metropolitan Board of Works, this Act dividing the metropolitan area into 39 districts, subsequently made into 41, the Board to have jurisdiction over the whole of the metropolis.

The Act of 1855 constituted the Metropolitan Board the authority to exercise powers for the following named purposes:—

"(1) The maintenance of the main-sewers; the interception of sewage from the Thames, its conveyance to a distance from London, and its purification before being discharged into the river."

"(2) The prevention of floods from the Thames, with other ordinary duties of Local Boards."

"The Act of Parliament also provided that "The Board should prevent all or any part of the sewage flowing or passing into the Thames in or near the metropolis."

Experiments were made, not however how best and once for all to free the Thames from pollution, but how they should arrange for and construct sewage-outfalls into the river, and they then settled upon Barking and Crossness. Surely a strange mode of performing the task set before them and not complying with the requirements of the Act.

There were many outside public objections to this decision of the Board, and as the Government had retained the power to approve or object, they did object to this decision, and Sir Benjamin Hall appointed referees to examine and report on this proposal of the Board. The result was a big Blue-book, in which the referees objected to the Metropolitan Board's position of outlets to the river, and recommended outlets of their own, at points more distant down the river—namely, at Higham Creek on the south, at Thames Haven on the north. These proposed outlets the Metropolitan Board objected to on account of cost, and the Government at length withdrew their objec- and the Board had its way, and was then tion, repealed the 136th Section of the Act, 1855, empowered to borrow £3,000,000. In 1863, a further Act enabled it to borrow an additional sum of £1,200,000, the works to be completed in 1866, the cost being £4,200,000, additional sums having been expended on storm-water-sewers and crude sewage overflows to the river, within the inhabited area, from Chelsea to Blackwall, at a further cost of £400,000, and other large additions, making a total cost of £6,000,000. There are 82 miles of intercepting sewers, capable (it is said) of intercepting daily about 63 million cubic feet, or nearly 400 million gallons of sewage.* The sewers vary in diameter from 4ft. to 9½ft., 10½ft., and

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* Falls of rain have taken place over parts of London at a rate of 2 inches per hour; in tropical countries at rates up to 12 inches in 24 hours, and in May, 1889, at Hong-Kong, 30 inches in 36 hours. Sewers cannot be constructed to provide for such volumes of water. These floods must consequently pass down open conduits or over the surface.

* If this is so, there is a great defect in the arrangement of the intercepting low level sewers, seeing that the one along the Embankment from Westminster to Blackfriars does not carry its due proportion of this volume.

12 ft. diameter. There are also reservoirs at the outlets, and pumping stations intended to lift and store sewage during the inflowing tide, to discharge two hours after the set in of the ebb. The Barking sewage-reservoir has an area of 9½ acres, the Crossness reservoir being, in surface area, 6½ acres.

These reservoirs have not sufficient capacity to store sewage until the tide has turned, so that in every wet period the crude sewage, with its silt, forces a passage to the river when flowing and ebbing, and, under existing arrangements, must continue to do so, mud-barges notwithstanding.*

STATISTICS AS TO THE MAIN SEWERS.

North Side of the Thames.

Site of Sewer.	Length in Miles.	Diameter.
Northern High Level Sewer	7½	From 4 ft. to 9½ ft. and 12 ft.
Northern Middle Level Sewer	9½	,, 4½ ft. by 3 ft. to 10½ ft.
Piccadilly Branches	2¾	,, 6¾ ft. to 10½ ft.
Northern Low Level Sewer	8¼	
Hackney Branch	2½	
Isle of Dogs Branch	1⅞	
Western Sewers—Main Line	5⅛	,, 4 ft. by 2ft. to 5 ft.
Fulham Branch	1⅓	,, 4 ft. by 2 ft. to 5 ft.
Acton Line	1⅜	
Northern Outfall Sewer	5½	Two culverts each of 9 ft. 6 in.

Engine Power.

At Abbey Mills Pumping Station there are 8 engines, each of 142 horse power, capable of raising 15,000 cube feet of sewage per minute to a height of 36 feet.

At the Western Pumping Station, at Pimlico, there are 4 engines, of 90 horse-power each, with a supplementary engine of 120 horse-power, capable of raising 6,000 cubic feet of sewage per minute, to a height of 18 feet.

South Side of the Thames.

Site of Sewer.	Length in Miles.	Diameter of Sewers.
Southern High Level Sewer	5⅜	From 4½ ft. by 3 ft. to 10½ ft.
Effra Branches do.	7¼	,, 7 ft. to 10½ ft.
Southern Low Level Sewer	9½	,, 4 ft. to 2 culverts, each 7 ft.
Bermondsey Branch	2¾	,, 5 ft. to 5½ ft.
Southern Outfall Sewer	7½	,, 11½ ft. diameter.

At the Deptford Pumping Station there are 4 engines, each of 125 horse-power, capable of raising 13,000 cubic feet of sewage per minute, to a height of 18 feet.

At Crossness Pumping Station there are 4 engines, each of 125 horse-power, capable of raising 17,000 cubic feet of sewage per minute, to a height of 10 to 30 feet.

LONDON.

The area covered by London is given as 117 square miles, the population being about 5,500,000, residing in 750,000 houses. The rateable value is—£38,462,493, gross; £31,592,387, rateable; and the Metropolitan Board, in its life of 33 years, has expended about £75,000,000, leaving a debt of about £17,000,000 sterling. There are some 2,700 miles of streets having sewers, and intercepting main and branch sewers, ranging from 12 feet in diameter to 9 inches diameter, with probably some seven or eight million lineal yards of house drains, and more than half a million water-closets. But yet London is not by any means, in all respects, in its sanitary works and appliances, perfect. It is, however, more nearly so than any other city in the world, as is shown in its continuing low death-rate.

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* The inflowing tide, at times, brings the sewage above London-bridge, and does not take it back, but leaves it to rise and fall for several tides.

The cleansing and scavenging of London are not by any means so perfect as they may be made (but this question deserves a separate paper). The black-mailing by parish vestry dustmen should be entirely abolished. Macadam should not be used in main streets and squares, as it becomes dusty in dry weather, and muddy in wet weather, every ton of broken stone laid down in the year having, for the most part, to be removed in the form of dust or as mud.

As a summary to this portion of my paper, I may say that which I believe to be in the main true, namely, that London, on the whole, is the best sewered and drained city at this day, and that at no period of history has there been a city, in this respect, so complete. The sewering of Rome, in her greatest period, sinks into insignificance when compared with that of the London of our great and good Queen Victoria.

The Metropolitan Board, I have shown, was, by the Act of Parliament of 1855 which established it, instructed to free the River Thames from pollution by sewage. The first clause in the Act sets forth as under :—

> (1) "The maintenance of the main sewers, the interception of sewage from the Thames, its conveyance to a distance from London, and its purification before being discharged into the river."

But how did the Board interpret this clause? The Board and its engineer stated that—"The Act of Parliament provided that the Board should prevent all or any part of the sewage from flowing or passing into the Thames in or near the metropolis." (See the Board's final report, page 11.) I think, however, that the Board and its engineer must have been reading "The Tale of a Tub," and have read the Act as the brothers read their father's will.

I quote again from the Board's final report, page 11 :—

> "The Board, as soon as possible after its formation, applied itself to the consideration of what was undoubtedly the most important question with which it had to deal—namely, the improvement of the sewage system, and the diversion of the sewage from the Thames as it flowed through London."

This again is, however, a begging of the question, as the instructions of Parliament were to the Board to prevent a continual pollution of the Thames by sewage. If it did not mean this, why sanction an expenditure of six millions of money to bring about this all desirable result?

DISPOSAL OF THE SEWAGE.

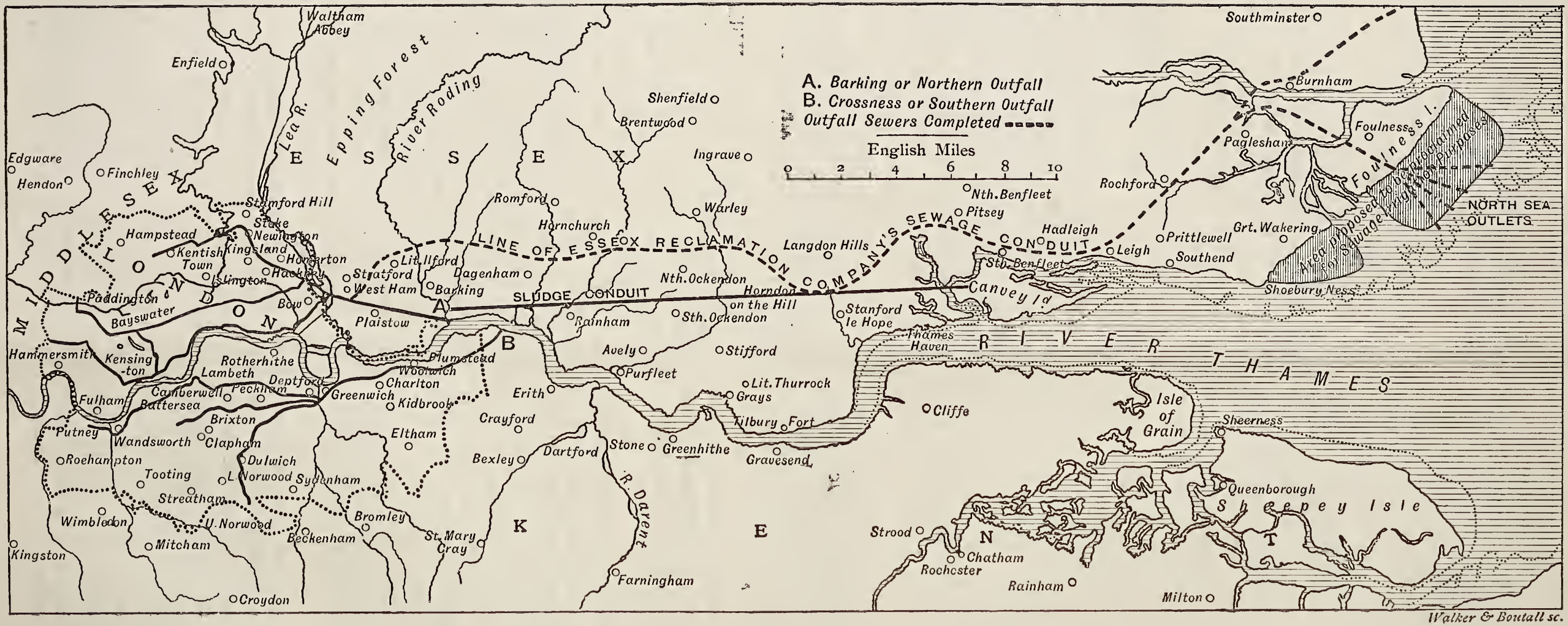
The Metropolitan Board, in its annual report, page 19, further states :—

> "The authors of the Metropolis Management Act would certainly seem to have contemplated the possibility of a profitable disposal of the London sewerage, for the 135th section concludes with a provision that the Board may sell or dispose of the sewage and refuse from the sewers, as it may see fit, so as not to create a nuisance."

But how could the Board sell and dispose of the sewage if they turned it wholly into the river?

Again, how did the Board interpret this clause? Not that they, the Board, were to make provision for the utilisation of the sewage, but that they, by advertisement. should try to find some second parties to do this most important portion of the work imposed upon them. And so, in 1860, the Board, by public advertisement, asked for offers from outside persons who might be willing to undertake to utilise the sewage, a period of six months being allowed for the submission of offers. Out of this advertisement came six offers.

In 1865, Messrs. the Hon. William Napier and Colonel Hope, V.C., proposed to take the sewage from the Barking northern outfall sewer, and to convey it through conduits to the Foulness Sands, and there to dispose of it for agricultural purposes, having outlets to the North Sea shore, the agreement providing for a division of profits between the concessionaires and the Board. The capital was to be £2,000,000 sterling, and £25,000 was to be deposited with the Board, to be held by them up to the completion of the conduit; but in the event of the work not being carried out, the deposit was to be forfeited. To enable the concessionaires to carry out their contract, in June, 1865, they obtained an Act of Parliament, under the title of "The Metropolis Sewage and Essex Reclamation Act," which was passed. The company having thus been formed, a contract was entered into for the construction of the sewage conduit, and the works were proceeded with for a short time. The shares were not, however, taken up by the public, the works were brought to a stop, and the money expended (I have heard that it was about £250,000) was lost, with the £25,000 deposited with the Board. A most



Walker & Boutall sc.

PLAN OF THE THAMES FROM LONDON TO THE SEA.

SHOWING THE PROPOSED OUTLET FOR SEWAGE TO THE NORTH SEA.

melancholy story; and, for those who subscribed the money, a miserable ending.

In 1867, Mr. Ellis tendered for the sewage on the southern side at Crossness, but no person offered to take shares, and, fortunately for the outside public, this scheme failed. Subsequently persons holding patents or having schemes for making a manure out of sewage deposit—"sludge"—have been allowed to experiment at their own cost, but all of these experiments have failed*.

THE THAMES CONSERVATORS COMPLAIN OF METROPOLITAN MUD.

In October, 1877, the Conservators of the Thames brought forward a complaint "that mud-banks had been formed by the discharge of sewage from the outfalls," and they called upon the Metropolitan Board "to remove them by dredging," as provided for by "The Thames Navigation Act, 1870." The Board, however, set up—that which was taken as proof—that there were no sewage sludge-banks to dredge, and after an inquiry which began November 4th, 1879, ending April 24th, 1880, they utterly defeated the Conservators. The costs and results of this trial apparently proved enough for the Thames Conservators. If, however, the crude sewage did not deposit sludge to form mud-banks in the Thames at this time, where does the sludge now extracted at Barking—to the extent, it is said, of 3,000 tons per day—come from? I am satisfied that not less than from 1,500 to 2,000 tons per day was passing with the sewage to the Thames when the Conservators were beaten in their arbitration.†

Then comes in another formidable Royal Commission.

In 1882, complaints were again made to the Secretary of State by the City Corporation, as sanitary authority of the port of London, and by the inhabitants of Erith, that the Thames was grossly and injuriously polluted so as to be injurious to health, and a Royal Commission was appointed "to inquire into, and report upon the allegations and as to the system under which sewage was then being discharged into the Thames by the Metropolitan Board; whether there were any evil results therefrom; and, in that case, what measures could be applied for remedying or preventing the same."

This Royal Commission was comprised of the most eminent engineers and chemists of the day, with that most able Judge, Lord Bramwell, as chairman. The Commission made inquiries and published two voluminous reports, with conclusions and recommendations, as under:—

1. "That the London sewage ought not to be discharged in its crude state into any part of the Thames.

2. "That the solid matter in the sewage should be separated from the liquid by some means of deposition or precipitation; and should be applied to the raising of low-lying land, or be burnt or dug into land, or be carried away to sea.

3. "That the liquid portion of the sewage remaining after precipitation might, as a temporary measure, be then allowed to pass into the river. But that ultimately it should be filtered through land."

The Metropolitan Board at once accepted the second clause, neglecting the final recommendation, namely, that the liquid sewage should be purified by intermittent filtration through the soil.

The Metropolitan Board at once adopted this the sludge-separating process, passing the fluid so separated to the Thames, and most hurriedly let the contracts for mud-tanks and mud-barges, using chemicals at a large cost, trying to do that which chemicals cannot do, namely, produce a pure effluent, or one which will not ferment and pollute the river in hot weather.

I will not enter into the chemical question further than to say that, so far as I know or can learn anything reliable on the question, chemistry does not purify sewage; and that, consequently, it cannot produce a pure effluent. But we may probably hear something more on this subject from chemists, and not from engineers.

ABSTRACTS OF THE SEVERAL SCHEMES PROPOSED FOR THE MAIN SEWERING OF LONDON, 1857.

Mr. (now Sir Joseph) Bazalgette, Engineer to the Metropolitan Board of Works.

Outlets to the river at Barking, north side; Crossness, south side. Adopted.

The Referees' Plan (Captain (now Sir) Douglas Galton, Mr. James Simpson, and Mr. Thomas C. Blackwell).

These gentlemen, after a most elaborate and costly inquiry and report, recommended:—

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* Dean Swift, again, in his "Island of Laputa," has trenchantly indicated the type of our modern sewage experts and manure-making speculators.

† I have learned from a party working at Barking that, from present experience with the sludge removal, fully 4,000 tons per day may be anticipated, or 28,000 per week, or 1,456,000 per annum—£145,600 per annum.

"An outfall, north side, at Thames Haven," with "an outfall, south side, at Higham Creek."

The "North outfall sewers, from the River Lee to Thames Haven," would have been about 23 miles.

The "South side, from the River Ravensbourne to Higham Creek," about 24 miles, or for the two sides, 47 miles.

These outfall sewers were estimated to cost £3,144,300, or £66,900 per mile.

Messrs. Maclean and Stileman's Plan.—August, 1857.

This provided for a main-outfall-sewer to the German Ocean, which was intended to commence from the mid-level sewer at Stratford, having a pumping-station lift of 37 feet, then in almost a direct line to Denzie Flats, and there making a reclamation of the Bay sands.

It may be noted that Mr. Maclean had been President of the Institution of Civil Engineers, and that Mr. Stileman was a vice-president of the Institution. The line these gentlemen indicated for their sewage conduit, and the reclamations they proposed to make, might be adopted now.

Mr. G. Munary & Mr. R. W. Mylne.—August, 1857.

Outlet to the Thames at Purfleet to be formed. This could not be allowed.

Messrs. Richardson & Clark's System.

Above ground by an enormous construction along the south side of the river to the estuary some 40 miles in length. This was a most extraordinary proposal, and would, if executed, have been enormously costly.

Messrs. Thornton & Parkson.

From Kensington Canal at Battersea in a direct tunnel sewer to Erith, and from Erith to Sea Reach, underground.

Messrs. Gotto & Stothert's Plan.

Low intercepting sewers, south and north, carried to the mouth of the River Lea. This could not be allowed.

DEEP TUNNEL SEWER.

There was a scheme proposed by some influential men, about 1852, to form a deep tunnel sewer, commencing at the west, and, passing beneath London in a right line to the east. This tunnel was to be at a depth of 70 to 100 feet, as the character of the strata might indicate the necessity when tested by shafts and borings. It was intended to be of capacity sufficient to receive the entire sewage of the metropolis; to have a fall from west to east, where engines of sufficient power should lift the sewage to the surface, to be dealt with in some form or other not defined. The proposal, however, never came to maturity, though the scheme was very taking for a time, and was influentially supported. Let us see what would have happened if an attempt had been made to carry it out. The tunnel would have been in water-bearing strata, which, during the progress of the work, must have been pumped; this would have laid all the deep wells in London dry. Any leakage from the sewer would have poisoned all the water in the lower strata, and when the sewer had been completed, it must have been relieved of the external pressure by unceasing pumping, as at the Severn Railway Tunnel. And such a sewage tunnel would have become putrid, so that abundant ventilation would have had to be provided, or the tributary connections would have been fatally tainted throughout all the surface sewers and drains connected. I name this case but only to condemn it, as the London streets are now so fearfully crowded by sewers, drains, gas-mains, water-mains, and telegraph mains, that the pipes are side by side and interlaced in a manner contrary to all proper regulations. So much is this the case, that I have little doubt but that some schemer will again try to revive a deep tunnel sewer.

COLONEL HOPE AND THE HON. WILLIAM NAPIER'S COMMERCIAL SCHEME.

This scheme, which may be said to have been adopted by the Metropolitan Board, was known as the "Essex Reclamation Company." It proposes a sewage-conduit "From near Abbey Mills to Southminster, Burnham Marshes, and Foulness Island," the Maplin Sands forming a very wide and flat shore. The surplus and wet-weather sewage was to pass to the North Sea, or German Ocean.

This scheme, as previously explained, was promoted and formed as a commercial speculation, the necessary capital having to be found by a company, which was to obtain an income from sewage-irrigation upon land to be acquired by lease or purchase; and also by land to be formed at or near the outlet by warping the marshes, or as might be reclaimed by sea embankments. Sewage-irrigation, however, was to be mainly relied upon to produce crops of various kinds, sufficient income to pay working costs, interest on capital, and a dividend. As previously stated, there was a guarantee to the Board for the fulfilment of this contract entered into, and a sum of £25,000 was, by the company, deposited with the Metropolitan Board. Land for an experimental sewage farm was then obtained, and sewage irrigation was carried on for some time, and was from time to time publicly advertised and inspected, but this did not tend, to any extent, to share-taking. When at length the promoters saw failure before them, they prepared the Barking Memorial, hoping to get a return of the £25,000 deposited as security for the completion of their contract, into the trnth of which memorial I was instructed by the Home Secretary of the day to inquire.

BARKING MEMORIAL.

This memorial, prepared, I assume, by the directors or others connected with the company formed by Messrs. Napier and Hope purported to set forth that the Metropolitan Board failed in its duty in not performing the task imposed upon it by Parliament, namely, in not having proceeded to purify the River Thames. This would, they no doubt thought, force the Board to relieve them from their contract. This memorial having been inquired into and reported upon by me, I do not purpose to give more than a few general heads, to indicate its character and its features.

On Monday, the 20th day of June, 1869, at 12 o'clock noon, in the Town Hall, Barking, I gave notice that I would then and there proceed upon the inquiry. I accordingly attended, read over the memorial and allegations, 13 in number, and continued the proceedings over six days, during which time I examined 38 witnesses, the questions and answers amounting to 3,561. My completed report was sent in to the Home Secretary in November, 1869. The evidence was, as such evidence usually is, of a contradictory character. But the memorial draughtsman had blundered so badly that I could not recommend any restraining action to be put in force on the Metropolitan Board. Nuisance to Barking Town could not be proved. The main navigation waterway of the Thames had not been impeded. Barking Creek had not been blocked with London sewage so as to prevent free navigation as heretofore; and, consequently these, the main allegations upon which the memorialists relied, utterly failed, and I so reported. But that the crude sewage of the metropolis did flow into the river, both with the ebbing and flowing tide, I saw. As, also, that the banks of the river, on both sides, and at the mouth of Barking Creek, had been loaded with viscid mud, sent in from the outfall-sewers. I also saw that the river was grossly polluted, both above and below the Barking and Crossness outfalls. This was self-evident both to sight and smell. I also learned and believed that fish had been killed, as stated in evidence. But these facts did not warrant me in reporting that the memorialists had proved their main allegations. If, however, a properly prepared memorial had been made by the Thames Conservators and the several towns on the river below the outfalls—Gravesend, for instance—and such memorial had set forth that the river was fouled by sewage detritus forming mud-banks so as to be injurious to barge navigation and to health, I should have so reported, and have recommended that an injunction should be issued, restraining the Metropolitan Board from continuing to break faith with Parliament by polluting the river with the crude sewage of the metropolis, so as to be injurious to health. I, however, may be mistaken in thinking that the Government of the day would have done any other than it has done—that is, to leave the Metropolitan Board to their own devices.

WORDS USED IN VARIOUS MODES OF TREATING SEWAGE.

Having served on two Royal Commissions to inquire into the question of sewage treatment, I will content myself with stating broadly some facts which I have been obliged to verify:—

In the first place, the word "purify" is not applicable to any form of sewage treatment; we may, however, use the word "clarify."

The word "disinfect" cannot properly be used as applicable to a successful treatment of old, corrupt, and putrid sewage, or human excreta, on account of uncertainty and the enormous cost. To disinfect the sewage of the metropolis would cost millions sterling per annum, and have no certainty about it. The late Dr. Parkes communicated this to the War Department in a confidential report, and stated that the most powerful disinfectants, even when used in excess, did not give safe results.

Clarification may be accomplished temporarily by precipitants, but sufficient of the salts of sewage will remain in the liquid to permit of putrefaction when it is poured into rivers and exposed in warm weather.

Clarification by a use of chemicals will cost from £1,500 to £3,000 per annum for each million gallons of sewage per day, so that to clarify the 150,000,000 of gallons of metropolitan sewage, at £1,500 per million gallons, would cost £225,000 per annum, but to clarify at £3,000 would, of course, cost £450,000 — and the clarified water when returned to the Thames would become offensive in summer. But clarification, mud-barges to sea, and all attendant expense will not cost less than £3,000 per million gallons, or £450,000 per annum. I am satisfied, however, that I have very much under-estimated the volume of sewage and the weight of sludge to be dealt with. I shall not be surprised to learn that in wet seasons the weight of sludge may be 3,000 tons per day. In fact, when the entire volume of sewage is dealt with, and the sludge is fully extracted, it may be found to reach 4,000 tons a day, or 28,000 tons a week, or 1,456,000 tons per year, costing, as previously stated, £145,600 per annum. This calculation has been made by one conversant with the work.

SEWAGE IRRIGATION.

Sewage irrigation has been carried on in England and Scotland a sufficient length of time to show that it is the cheapest and most effective mode of treating sewage yet tried, and where land is obtainable at agricultural prices, and the sewage can flow to the land, that there an income can be earned by the process. There are some thirty or more places in England where sewage irrigation has been in use a sufficient number of years to permit inquirers to be satisfied with the results, as at Banbury, Lodge-Farm, Barking, Bedford, Birmingham, Blackburn, Cheltenham, Chorley, Croydon, Craigentinney-meadows, Doncaster, Harrogate, Leamington, Merthyr Tydvil, Oxford, Rugby, Tunbridge Wells, Warwick, West Derby, Wolverhampton, and Wrexham.

At Berlin, the sewage of the city is lifted by steam-power to a height of 130 feet, at a cost of £12,000 per annum. Upwards of 2,000 acres have been purchased at a cost of £400,000, and this land is laid out and cultivated under sewage. The distance of the sewage farm from Berlin is about ten miles. The city authorities are said to be satisfied with the results. Paris has appropriated land for sewage irrigation for some years at Gennevilliers and some other places, to the extent of 12,350 acres. Steam-pumping power is used, and the river Seine is crossed. The municipality is so satisfied with this work, that the engineer, the late M. Durand Clay, is to have a statue.

Irrigation has been practised in China, Japan, Ceylon, and Italy, upon an enormous scale time out of mind; and in England water-meadows are successfully cultivated. At Edinburgh, the sewage-grown grass feeds dairy cows, the milk being used in Edinburgh. The London sewage may be turned into milk and butter which will be wholesome.

AN APPROXIMATE ESTIMATE.

The volume of crude sewage to be dealt with, if taken at 150,000,000 gallons per day, will represent 670,000 tons. Containing, say, 150 grains of solids per million gallons, this will about equal 10 tons of sludge per million. So that 150,000,000 gallons will represent 1,500 tons per day of sludge to be removed in barges. So that there will be 547,500 tons of sewage-sludge to remove, or get rid of, per annum. To consolidate it by sludge presses at 2s. per ton, would cost £54,750 per annum. To barge it to sea, there must be not fewer than six barges of the largest class, as the out and home voyage will be about 70 miles. Each barge to take 1,500 tons of sludge, containing at 90 per cent. of water, 1,350 tons of water to 150 tons of solids. But on testing the barge-load before discharging it, 95 and even 97 per cent. of water has been found. Taking, however, 95 per cent., there will be 1,425 tons of water to 75 tons of solids. Did it ever before enter into the heads of any body of men—engineers and representatives of Vestries—to perpetrate such operations? It must be remembered that the crude sewage flows to the outlets with its solids, and if pumped into the proposed sewage canal or conduit, it would flow to the North Sea, or on to any land used for irrigation or warping, as at Foulness Island.

It is not my intention to raise the chemical question as to the use and nature of chemicals for sludge disinfectants, this I must leave to the chemists. The sludge-tanks and the sludge-barges will in hot weather become putrid, and to arrest this, chemicals may be used, the cost being estimated very high. With fresh sewage flowing at once over land or to the sea, very few chemicals need be used, as the land will at once disinfect it. The sea will at once dilute and disperse it, as in the river Mersey, where the crude sewage of Liverpool, Birkenhead, and all the towns on the river and estuary pass harmlessly to sea.

THE NEW SLUDGE WORKS.

Contracts were let on the eve of closing the old Board to the extent of £741,000. Add to this extra land, fencing, workmen's houses, new mud-barges, at more than double cost by reason of the rise in iron, steel, and labour, and it appears to me that the legacy in this form will exceed £1,000,000 sterling. Interest on this with maintenance will be fully 5 per cent., which will equal £50,000 per annum. Wages may be £50,000 a year. The cost of chemicals will be in proportion to the quantity used, and may range from £50,000 up to £100,000 per annum, or £200,000 per annum on the whole. And all for what? Not to prevent pollution of the Thames, as the clarified sewage will ferment in the river, will kill fish as at present, and make the water foul-looking and offensive. Chemicals have been tried at many places to see if they would purify sewage, but ever with the one result—namely, to produce an effluent which becomes putrid, offensive, and dangerous. The new works land the County Council in a debt of about £1,000,000 sterling, with an annual cost of probably £300,000 per annum, and a polluting effluent. A vast nuisance establishment of 60 acres in extent.

It is never good policy to use hard names I admit, but I may quote an established proverb, and say, that these Barking and Crossness Works, as a gift to the new County Council, are equivalent to an entire herd of white elephants.

SUGGESTED NEW WORKS.

Pumping engines and apparatus to lift the sewage to the new sewage conduit, say at £100,000, or 46 miles of new conduit, at the estimate put down by the referees for the cost of their proposed southern and northern outfall sewers, which together measure 47 miles. Estimated at £3,144,300, pumping engines will make a total cost of £3,244,300, which at 5 per cent. for maintenance and redemption, will amount to £162,215 per annum to be set against £300,000, the probable costs of the works in progress.

I will not encumber this paper with any definite estimate as to income from sewage farming, as this will involve the question of purchase of right of way for the sewage conduit, and for outlet works. This feature of the scheme must grow with time. Areas for sewage irrigation may be formed to any extent, from 10,000 up to 50,000 acres, and there will be sewage enough and to spare for this large area. The agricultural value of town sewage has been tried and estimated, over and over again, both in England and on the Continent. A Royal Commission, with the honoured name of Sir J. B. Lawes, Bart., at its head, estimated the commercial value of crude sewage at 2d. per ton to a farmer, taking it as he wanted it; but only at ½d. per ton if he must take it and dispose of it all the year round. The London sewage is the richest known in manurial ingredients, and amounts in daily volume, at its lowest estimate, to 670,000 tons, which at 2d. per ton, will amount to £5,583; and at ½d. per ton to £1,395 per day; or about two millions sterling, in the one case, and at ½d. about half a million sterling. I cannot help dealing with these figures, enormous as they are; but when I know that cultivated sewage lands bring in, year by year, rentals of from £15 to £20 and even £30 per acre, there must be more than a grain of truth in these very large figures. I do not, however, plead for the purification of the Thames on the score of any probable income to be derived from sewage farming, as this would be begging the main question, which is to free the River Thames from pollution at all costs by a sewage conduit, and additional steam pumping, and, by a tunnel under the river, bring the south sewage to Barking, sending the whole eastward, once and for all, to the great North Sea, and then to let reclamation of land and sewage irrigation follow.

SEWAGE CONDUIT FROM LONDON TO THE NORTH SEA.

The length of the conduit from Abbey Mills, eastward to Foulness Island, Southminster and Burnham Marshes, will be about 46 miles, through an agricultural district, and sea outlets must, in the first instance, be provided along this shore over the Maplin Sands to low water of spring tides. This I consider is a work necessary to be done, if it could even be proved to be as fruitless of pecuniary results as the sewage precipitation and mud-barge process.

The conduit will be a canal, or new river, for the conveyance of sewage in its fresh state, along which it will flow unceasingly at not less than two miles in the hour, to be as unceasingly disposed of at the eastern terminus. The question may be put—But will it not be a nuisance to the neighbourhood in its course? My reply is, that the works must be designed and be executed so as not to be a nuisance. Portions will be covered, portions will be in tunnel, and some portions may be open, but at no point need there be one-tenth the nuisance there is now at the existing outlet works, nor more than at a well managed sewage farm, nor so much as from a heavily manured field.

The New River at London has a grade, or fall, of six inches per mile, and this inclination may be given, by similar means, to produce this grade; but there must be a head of about 23 feet, not, however, necessarily at one point, but be subdivided at several points; the reaches from fall to fall being level, velocity being obtained by overfall-weirs and sluices. The Bridgwater Canal is 30 miles in length, from Manchester to Runcorn, of course level, the outlet being by locks at Runcorn. The rate of flow is about one mile per hour. The flow along the London sewage-conduit is to be two miles per hour, so that the sewage of each day will pass from the junction with the metropolitan sewers at or near Abbey Mills, to the outfalls to the sea in 23 hours.

A CHEMIST'S ESTIMATE OF THE VALUE OF LONDON SEWAGE, 1857.

Mr. R. Etheridge estimated the value of London sewage for Messrs. Douglas Galton, James Simpson, and Thomas C. Blackwell, as under :—

Thames Mud.—Thames sewage is composed of animal matter, vegetable matter, human excreta in a state of decomposition, and living organisms of the class infusoria, diatomaceæ, zoophyta, and crustacea. The detritus consists of crushed road and street material, such as granite and other crystalline rocks, crushed flint, gravel, and earthy deposit. This is termed "crude sewage."

Analysis. — From the analysis of mean samples of crude London sewage, it was found that 100 tons of liquid possesses a manurial value of 17s. 7d. The suspended matter, "mud," is worth 2s. 2½d. The clarified liquid is worth 15s. 4½d., so that the cost of precipitation obtains in money value about one-seventh that of the entire sewage, and this is to be barged to the sea, whilst by far the largest value is to be sent to the river. If this would not putrify and pollute the river, there would be so much in its favour, but as seven-eighths of the salts of sewage remain in the fluid, plus some of the chemicals used, that which is most valuable as manure is wasted, and the injurious pollution of the river is continued.

The entire volume of the London sewage at 2,145,500 tons per annum, at 17s. 7d. per 100 tons, is worth upwards of £1,750,000 sterling; but 25 years ago the London sewage was valued at £1,000,000 sterling per annum.

Along the entire line of the proposed sewage conduit, sewage may be supplied to farmers, and dairy farms may produce milk for London. Italian rye grass may be grown and sold, as also turnips, mangolds, and other crops. In warm and dry summers hay may be made, and in wet seasons siloes. Land is not corrupted by sewage irrigation, but is improved, as the solids out of 100 tons spread over one acre of land would not give a surface deposit of 1-100th of an inch in thickness. In warm summer time 1,000,000 gallons of sewage may be utilised on one acre in one day, and where something like this volume is used, and the land is light and porous, a very small volume drains from the subsoil. In exceptionally hot weather no water flows from the land.

Where chemicals are used for precipitation, and the water so clarified is turned out unfiltered through land, and cattle drink it, the milk is not fit to be used. Cows will, however, drink crude sewage without apparent injury, but they had better have clean water supplied.

THE SLUDGE AND SLUDGE BARGES.

It will be possible to send sludge having 90 per cent. of water to any distance in open troughs or pipes, to be used in warping low land, and this mode of disposing of it will be far cheaper than barging it to sea. Enormous quantities of sand are dredged and passed through pipes to the shore, as in Holland and the Suez Canal. Diluted clay in brick-fields is also sent along open troughs considerable distances, and this form of conveyance for the sewage sludge may enable the County Council to dispense with sludge barges.

I say that this or some similar work must be carried out to free the River Thames from pollution, and that for this purpose the Barking and Crossness outfalls must subsequently be so altered, modified, and dealt with, as not to pass any sewage to the Thames, but, by a tunnel from Crossness to Barking, with the engine-power to lift the combined volume to the new canal or conduit. I say also that the crude sewage may freely and easily flow along the new conduit, to be used in irrigation, and so much as may not be so required in winter or in wet seasons can be passed on to the North Sea, in like manner as it now flows along the London intercepting-sewers to the present outlets, so that it will not be necessary to remove by precipitation, one pound weight of sediment, or use any chemicals, as the whole will flow in one continuous stream, at a rate not less than two miles per hour. Properly constructed apparatus can be adapted to float along the conduit, sweeping onward any deposit there may be.

This paper is a brief statement of the main sewerage of London, which most undoubtedly is a grand work for the Metropolitan Board to have devised and carried out for the metropolis, and if it had been really wise in its day and generation in devising proper works for dealing with the sewage so as to purify the Thames without any outfalls to the river, it would have deserved a permanent memorial to be a record of its great work, which all men might see and read through all succeeding time. But it has blundered over the Thames purification question until, in its last days, it has handed over abortive works which will cost the County Council not less than a million sterling to get rid of. But must this work remain? I say no, and no. It both must and will be abolished.

Look at this mighty city of London, with its millions of inhabitants; look at the beautiful river, which flows gently down in silver sheen from its upper reaches, and supplies wholesome water for the swarming population inhabiting its banks; look again at its lower reaches, the great highway to all the nations of the earth, whose ships, laden with the produce of all climes, crowd the wharves and docks; and then say if the final result of the main drainage question shall be to leave the grand old river a black, loathsome, stinking ditch! My final conclusion is that the sewage must be disposed of out of the River Thames.

DISCUSSION.

Mr. J. G. RHODES (late chairman of the Main Drainage Committee of the London County Council) said he would state shortly how the question now stood, without entering into past history; but referring to the recommendations of Lord Bramwell's Committee, and showing how far they were carried out, and how far they stopped short of doing what was necessary to prove whether the plan was a success or a failure. That Royal Commission reported that it was not necessary or justifiable to discharge the sewage in its crude state into any part of the Thames. That was clearly the opinion of the Metropolitan Board; and they attempted to carry out that recommendation, and proceeded to construct the Barking and Crossness outfalls. The committee also said that some process of deposition or precipitation should be used to free the sludge from the liquid portion, and that such a process might be conveniently applied at the main outfalls. The Metropolitan Board accordingly did so, and also adopted the last alternative suggested with regard to the sludge, that it might be applied to the raising of low lying land, or be dug in or burned, or carried away to sea. The report also said that the sludge might be dealt with in such a way as not to be a nuisance to the neighbourhood where the process was carried on, and as a preliminary and temporary measure the liquid portion might be allowed to escape into the river, but only at a particular position. The plan had not yet been fully tried, and therefore they could not say whether the subtraction of the sludge would sufficiently relieve the river from nuisance, so that the continued passage of the effluent might be permitted. His point, however, was that the recommendations of the Royal Commission had been carried out by the Metropolitan Board as far as possible during the time they held office; thes large works had been erected, and in order that they might have a fair trial they ought to be allowed to remove the sludge deposited. It was not a question whether a right or wrong method of precipitation was adopted; though the one adopted was the result of observation over a large area in all parts of the country. But it had hitherto been found that when you precipitated sludge you always had about 80 per cent. of water left in it, though possibly that might be reduced in future. The report of the committee, which was yesterday defeated in the County Council, was in its essence a mere paraphrase of the recommendations of the Royal Commission, up to the point which had practically been arrived at. They wanted to remove daily about 3,000 tons of sludge, and the simple question was what was the best method of doing so, at all events for the present. There were two sludge barges which were not adequate to the business, and therefore it was suggested that others should be added. It might be shown by-and-bye that a cheaper mode of disposing of sludge than cargoing it away was practicable, but the first thing was to get rid of it somehow, and they had had experience of the use of ships, and knew what they could do. It seemed to him, therefore, that it was the bounden duty of the County Council to continue in the line which had been shown to be practicable, and to give a reasonable trial to these new works which had been constructed under the direction of the Royal Commission. The state of the river last summer was disgraceful—and why? During the construction of the works it was absolutely necessary to get rid of the sewage somehow or other, and it had to be cast into the river at all states of the tide. The consequence was that the bed of the river for a considerable distance above and below the outfalls was covered with sludge; it had, in fact, been converted into a great sludge-settling tank, and that went on over a period of something like two years. Last summer it all bubbled up, and gave what was called "black water," and so horrible was the condition of things that it was necessary to deodorise the river with one of the ships. The process went on for a couple of years, but it only made itself known by the results in the hot weather, and if the sludge were not removed, next summer the same evil would be repeated and intensified. When he heard the statement that the recommendations of the Main Drainage Committee had been defeated received with approbation, he could only conclude that the danger was not apprehended by the public. If they went on pouring a portion of the sewage into the river in its crude state until other means of dealing with it were provided, they would be only preparing fresh mischief for next summer. His view was that, although there might be better means provided for getting rid of the sewage, these means would require time to think out and Parliamentary power to carry out, and in the meantime the immediate nuisance ought to be got rid of. Last year he was chairman of the Main Drainage Committee, and strongly urged upon it, before the recess, the desirability of appealing to the Council on this point, and asking for authority to obtain designs for two more boats, in order that they might be prepared to deal with the matter when the hot weather came. The committee did not agree with him, the question was postponed, and was defeated in the Council on the previous day. The recommendation was supported by a vote of two to one in the committee after full consideration, and it seemed to him that the only practical course at present, while reserving their opinion as to what might be the best course in future, was to have accepted that recommendation.

Admiral Sir **FREDERICK NICOLSON**, Bart., C.B., (chairman of the Thames Conservancy Board) said that they now heard from the successors of the Metropolitan Board of Works that the river was full of sludge, but some years ago they were told exactly the reverse. Sir Robert Rawlinson had referred to the upper part of the river, and called it the "Silvery Thames," and if that portion of it had been under discussion he might have given a most satisfactory account of it, but they were dealing with another part, and a very different state of things. Allusion had been made to the arbitration between the Conservators and the Board of Works, but in that case they were unfortunately tied down by a very imperfect Act of Parliament, the clauses relating to dredging being so circumscribed that their hands were completely tied, and that was the chief reason of their failure. They had to prove, which was almost impossible, that the navigation was absolutely obstructed by certain shoals produced by the sewage outfalls. No one could deny that the traffic was going on, though just below the southern outfall, in Halfway Reach, what was once the proper channel for heavily-laden ships, which was on the south side, had become so shallow, solely by deposits from the outfall, that vessels had to go along under the northern shore, where a good deal of dredging had taken place. As they could not show that these vessels were obstructed, because they avoided deposits of mud, the case failed. He had seen, in Erith Bight, a pole pushed down 10 or 12 feet into sewage mud of the most fetid character, which was never there before the southern outfall was opened. However, he did not think the money spent in the arbitration was entirely thrown away; a great deal of evidence had been collected, and it probably paved the way for the subsequent action on the part of the Corporation of London, who brought the matter before Lord Bramwell's Commission, when the whole question of pollution was gone into, the result being a very streunous report that the sewage ought not to go into the river at all. On one occasion, when Lord Bramwell went down to Woolwich to inspect the river, he was perfectly horrified at its condition. The whole reach was one mass of ink of the most horrible odour, and they traced this, which was supposed all to go out with the ebb tide, going up as far as Limehouse with the flood. It was only in very dry seasons and hot weathers that this extreme unpleasantness took place, but looking at it from a seaman's point of view, if these plans for disposing of the sewage of London went on, there must be a series of shallows formed in that part of the river. His Board hailed with delight any scheme which would keep the solid contents of the sewage out of the river, which was naturally remarkably free from shoals and easy of navigation.

Mr. **ÆNEAS SMITH** said, as a member of the Main Drainage Committee of the County Council, and the proposer of the motion that a civil engineer should be appointed to confer with the engineer of the Council, he had declined to order more sludge ships. Mr. Rhodes spoke of the thoroughness with which this question was dealt with by the committee, but he, as a member of it, was not at all satisfied with the present condition of things. He thought London was in a disgraceful condition in this matter, and that there ought to be a thorough and complete inquiry, and he went to the Council determined that before he would vote for the expenditure of £50,000, to be followed by one or more similar amounts, he would know what the end of the business was to be. He had very little faith in chemicals; for every 50 tons of poison which were removed, 350 tons were thrown into the Thames, and he was not prepared to see all this vile matter stirred up by the paddles of steamers, and he thought it ought to be disposed of in some other way. A great deal had been said about the expense, but that did not rest on the shoulders of the County Council, they were not responsible for the millions which would be spent at Barking and Crossness, this was handed down to them. Some of them thought it might be wise to propose a resolution that the work should be discontinued, and the contractors compounded with for what they had done, but it was found that very little saving could be effected, and, therefore, there was no alternative but to finish the contract as far as Barking; what might be done with regard to Crossness was matter for future consideration.

Dr. ALFRED CARPENTER said it was very refreshing to hear such a statesman-like paper; and he commended the points which had been so forcibly put to the consideration of the ratepayers. The question raised by Mr. Rhodes, as to what to do with the sludge, ought not to arise, because if the sewage were dealt with properly, there would not be any sludge to remove. If a pint of beef tea were kept for a few days there would be plenty of sludge, but there was none there the first day or two. As soon as putrefaction commenced an immense amount of sludge was formed, and the great principle in dealing with sewage was to keep it moving until it was delivered on to the land. There were two things greatly needed at the present moment in London—meat and milk, and yet they were proposing to pour sewage, which would produce them both, into the sea. The ratepayers must not look to derive any profit from the utilisation of sewage; they would have to do as other localities did, provide an area of land on which it could be utilised, and let the agriculturists have the profit to be derived from its use. If the London County Council would bear this in mind, and provide land—either where Sir Robert Rawlinson suggested, or at Canvey Island, or as he would suggest on some of the waste lands round London, which were calling out for sewage, they would find thousands of acres not worth 5s. an acre which could be made to yield an average rental of £5 an acre, and the difference between those two figures would provide a fund out of which to pay interest on the capital required. This question was of the utmost importance to the nation. He had watched the utilisation of sewage on land for 25 years, and he could say that the subsoil was almost as pure a yard down as it was before it was used. The growth of crops had removed all this stuff which was spoken of as sludge, and it had been formed into meat and milk, and added materially to the wealth of the district. The death-rate of London was low, but nothing like so low as that of the area he referred to round the sewage farm, for in that area, involving a population of 5,000, the death-rate during the last ten years had never risen above 14, and it was not on account of a low birth-rate, for that was 34. There was an entire absence of zymotic disease. He hoped the County Council would take the matter up seriously and devise measures for preventing the evils which would otherwise come upon them, not immediately but in a hundred years time, and which would not only make the neighbourhood much more unhealthy than it had ever been, but would prevent the river being what it had hitherto been—a highway to the port of London.

Colonel JONES, V.C. (Wrexham), said he could entirely endorse what had been said by Dr. Carpenter. He had been living on a sewage farm for 18 years, and had enjoyed the best of health and so had his family. He found every drop of sewage valuable, and had generally managed to satisfy the Corporation to whom he was sanitary engineer. He was now engaged in carrying the sewage of Wrexham two miles further to a new farm, solely because the present farm had been so improved that the landlord would not treat for the sale of it at any reasonable price. If a little place, with a population of 12,000, could afford to take its sewage two miles, the City of London could well go 20 miles to Canvey Island; which Sir Robert Rawlinson had indicated as the first outfall. That island contained nearly 5,000 acres, which would suffice for the solid and most offensive part of London sewage for many years, and surrounding it on the coast of Essex there were immense areas of cool land which would benefit by having sewage poured upon it. He looked upon Canvey Island at a sort of safety valve and experimenting ground to which the metropolis could carry its sewage, and be content only to take it elsewhere when there was a demand for it. At Wrexham he found the tenant of the new farm to which the sewage was to be taken was only too delighted with it, and his own successor intended to continue it. In the same way, if an experiment were made at Canvey Island on a small scale, there would soon be a demand from the neighbourhood. With regard to the question before the County Council, he might mention that a proposal had been made by his partner, Mr. Bailey Denton, and himself to relieve them of the expense of ships to take the sludge to the Nore, by laying down a 12-inch pipe in duplicate, about four feet above the surface, along the Essex coast, to conduct the sewage under pressure. They had been advised, too, that the existing engines and pumps were capable, with very slight alteration, of putting pressure on sewage in a 12-inch pipe equal to 200 feet head, if required, to drive the whole of the sewage in a semi-liquid state—and if it were nct liquid enough it might be made so—to Canvey Island, where it could be disposed of in improving and raising the land to the level of high tides, which at present had to be banked out.

Dr. CHARLES DRYSDALE said that all European nations were looking to England for a solution of the sewage question, and many of them had sent engineers over here to study what had been done. Paris had now a very successful sewage farm of 1,500 acres, which produced most magnificent crops, and the effluent was so pure that anyone could drink it, as he had done himself. In Berlin, also, where the authorities had sent engineers to study English sewage farming, they had now about 11,000 acres on the north and south, and not a particle of sewage was now sent into the river. It all went on the land, winter and summer, and Professors Virchow and Koch both said the effluent water was the purest to be found anywhere. Yet London, the metropolis of the world, still continued the ridiculous system bequeathed to it by the Metropolitan Board of Works, which was silting up the river, and causing it in the neighbourhood of Woolwich to be most pestilential in summer, and all the valuable manurial products of the population to be wasted. It was the same with Dublin and Glasgow; these three towns were a disgrace to civilisation. Every possible plan had been tried, and it was well known now that the only possible way of purifying sewage was by passing it through fitting soils. On the proposed line to the North Sea there were at least 40,000 acres which might easily be bought at a cheap rate, and would soon be found profitable. Two hundred thousand cows could be fed on the grass and root crops which could be raised upon them, and then London would be able to get a supply of milk, which was much wanted.

Sir ROBERT RAWLINSON said he would remind Mr. Rhodes of one fact, viz., that the so-called clarified sewage, though it might look perfectly clear, was truly polluting sewage, and when it went into the river it was as capable of producing a stench and doing mischief as it was with the sludge, minus one point in eight. At Leamington, the A B C people proposed to make a valuable manure by their chemical process, but they were driven out of the place because the effluent they sent out polluted the river, and they were restrained by injunction. He had purposely avoided going into the question of irrigation in any detail, though no one in the room had had wider experience of it. He had officially examined every sewage farm in England, and many of the large ones abroad, and he could say, confidently, that if sewage were to be put to its best uses, and dealt with so as to occasion the least loss, it should be put upon land. If he had proposed, however, to make sewage farms all the way down from Barking, he knew many people would say he was going to poison all the wells and create a nuisance, and therefore he had provided a conduit, without saying anything about utilising it on its way to the outlet. He was quite certain, however, that as soon as the landowners and farmers saw the value of it, every acre of land along the conduit would be glad to have the sewage, and before many years every gallon would be taken before getting to Canvey Island, and none would have to go into the sea. The legacy which the Metropolitan Board had left their successors with regard to the sludge treatment, was one of the most outrageous things of modern times. They ought to have known that what they termed clarified sewage was not clarified so as to prevent it being mischievous. When he held the inquiry at Barking, they told him there was no crude sewage going into the Thames, and found witnesses to swear there was no deposit at Barking, when at the very time there was ten or twelve feet of sludge. Yet he was obliged to report that it was not proved that the mud came out of the metropolitan sewers, because there were so many men swearing it did not. He was sorry for the way the Conservators were beaten in their action, but it was proved in the arbitration that no sludge went into the Thames to be dredged, but where did the 3,000 tons every week come from? There had been no creation of sludge since that period. When the inquiry was held, it was stated that the tanks were to receive the sewage, and that none was to enter the river except two hours after the turn of the tide. It was then going in at all states of the tide, had done so ever since, and would continue to do so. The best thing for the County Council to do, would be to abolish all methods of dealing with the sludge, establish a conduit as shown on the map, and deal with it on the land. There would not be any profit on it, but the income would be far more than enough to pay the interest on the money required to promote the conduit.

Mr. W. C. SILLAR wished to say that there was not a word of truth in the statement as to the A B C process at Leamington. It was only tried there on sufferance for two years while land was being prepared for an irrigation farm, and when the term expired, they received the thanks of the Corporation and every satisfaction was given while it was in operation. As to an injunction, he did not know where Sir Robert Rawlinson got his information from; but it was entirely without foundation.

Sir ROBERT RAWLINSON said the Earl of Warwick told him he would obtain an injunction, so that the A B C Company was removed by the terror of an injunction if not by its actual operation. The river was most abominably polluted by the effluent.

Mr. SILLAR repeated his denial of this statement.

The discussion was adjourned to Wednesday, the 15th January.

General Notes.

CEYLON TEA TRADE.—The total value of Ceylon tea in bond in 1880, when the trade commenced, was £5,024, and in 1888 the total value was £1,155,095. At the present time there are 200,000 acres in Ceylon under tea cultivation. During 1889 16 per cent. of the tea consumed in England came from Ceylon, 50 per cent. from India, and 34 per cent. from China. The total consumption was 155,160,000 lbs., made up as follows:—Indian tea, 78,010,000 lbs; Ceylon, 25,350,000 lbs.; China, &c., 51,800,000 lbs.

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FRIDAY, DECEMBER 27, 1889.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

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JUVENILE LECTURES.

The usual short course of lectures adapted for a juvenile audience will be given on Wednesday evenings, January 1 and 8, by Professor VIVIAN B. LEWES, on "The Story of a Flame."

The lectures will commence at seven o'clock. Members requiring tickets are requested to make early application for the few that still remain.

As all the available accommodation will be required for those members who have applied for tickets, it will be understood that no member can be admitted without a ticket.

LIST OF MEMBERS.

The new edition of the List of Members of the Society is now ready, and can be obtained by members on application to the Secretary.

Proceedings of the Society.

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CANTOR LECTURES.

MODERN DEVELOPMENTS OF BREAD-MAKING.

By WILLIAM JAGO, F.C.S., F.I.C.

Lecture I.—Delivered November 23, 1889.

In giving a course of lectures on such a subject as that of the "Modern Developments of Bread-making," the thought very forcibly occurs to me that ten years ago this night, Professor Graham commenced in this same lecture-hall, a course of lectures on the very similar subject of the "Chemistry of Bread-making." Among the many distinguished Cantor lecturers, Dr. Graham has been one of the most distinguished, and no subject has been more ably treated than was bread-making by him on that occasion. Dr. Graham then laid what I venture to term the foundations of modern scientific bread-making; the object of the present course is to describe and place on record the progress which has been more recently made in bread-making, considered in its practical aspects. As a necessary consequence of the wide extent of this subject, I shall be compelled to omit reference to many matters interesting in themselves, but not directly falling within the scope of the present lectures. My task of selection has been rendered the easier by another course of Cantor lectures, delivered in 1888, by Mr. A. Gordon Salamon, in which the subject of Yeast is treated most exhaustively, and in such a way as to materially lighten my labours in that direction. My second lecture will be devoted to fermentation, and if those who have not as yet read Mr. Salamon's lectures will do so during the interval, they will find themselves greatly helped by so doing, as I shall have to deal very briefly with many matters explained at length by Mr. Salamon.

As an introduction, it will be necessary for me in a few sentences to describe in outline those bread-making processes commonly adopted. Everyone is familiar with the appearance of flour, the white light powder we have here before us. Everyone, too, knows that this light powder produces, when mixed with water, a most tenacious mass, to which we give the name of dough. Notice that on thoroughly stirring the two together in this little machine, which has been specially made for me by Mr. Pfleiderer, we have a substance thoroughly answering to the description I have just given of it. Notice also that on mixing oatmeal in the same way, we have only a sandy mass with little or no cohesion. We are so accustomed to flour and water forming dough that we almost always associate the idea of toughness with that of a wet mass of flour. The two conditions are not, however; inseparable; we will mix flour in the next place with another liquid, and we get a sandy mass just like that of the wetted oatmeal. The liquid used in this case is alcohol: if we substitute water containing about 15 per cent. of common salt, we find that much the same result occurs. Further, let us take another sample of flour and mix in exactly the same proportions with water, and we find that the dough is much less tenacious than in our first experiment. This property of tenacity is affected, then, by the nature of the liquid used, and also depends more or less on the character of the flour. It has been necessary to touch somewhat freely on this physical characteristic of dough, because on it most largely depends the *rationale* of all ordinary bread-making operations. Ordinary bread can be distended into the spongy form with which we are all familiar because of this elastic condition peculiar to the dough from wheaten flour. It will be well to indicate here the principal constituents of flour, as I shall have to refer to them repeatedly in the course of my future remarks.

CONSTITUENTS OF FLOUR.

Partly soluble...	Ash, principally potassium phosphate.	
Soluble	Sugar (maltose). ...	Compounds of C, H, and O.
	Gum (dextrin).	
	Albuminous matter	Compounds of C, H, O, N, and S.
Insoluble	Gluten	
	Starch, a compound of C, H, and O.	
	Cellulose, a compound of C, H, and O.	
	Fat, a compound of C, H, and O.	

Of these bodies, it is the gluten which imparts the elasticity to the dough. By a process of washing, the gluten can be obtained in a comparatively pure state, and here we have the quantity yielded by 25 grams, or nearly an ounce of flour. This piece of gluten in its present wet state, weighs 10·5 grams; if dried in the hot water oven at a temperature about that of the boiling point of water, it loses about two-thirds its present weight, and would then weigh about 3·5 grams, equal to 14 per cent. of the whole of the flour. This mass of gluten has been prepared from the flour on which our first doughing experiment was made; this next piece was obtained from the second variety, which you will remember produced a dough of much less tenacity. The weight of gluten in this second instance is 29·5 grams, being considerably less than with the former flour. In this way it is shown that some connection exists between the quantity of of gluten and the tenacity of the dough. Notice also that these two glutens are very different in character: if we cut them down to the same weight, we should nevertheless be able to distinguish the two: the former is tough and springy, but the latter is comparatively soft and devoid of tenacity. Of these two flours, the former is a specimen milled from hard American wheat, the latter from soft English.

Having this tenacious mass of flour and water, the properties of which are due to the presence of this substance—gluten, the baker's endeavours are directed to so lightening it as to give the delicate spongy appearance shown in such a loaf as that we now examine. For all practical purposes, this is effected, in the enormous majority of instances, by the process of fermentation. Yeast is added to the flour and water, and at a suitable temperature. The sugar which has been already indicated as a constituent of flour, is split up into alcohol and carbon dioxide gas. The latter distends the dough, until it is sufficiently light and spongy to be placed in the oven. This process of panification, or bread fermentation, is conducted in an almost infinite variety of ways, which may however be usually classified under the three stages of ferments, sponges, and doughs. Some little explanation of each of these is necessary.

The ferment consists of a mixture of boiled potatoes and water mashed together until of a syrupy consistency. About six pounds of potatoes are taken to two gallons of water; the mixture is cooled to about 60° Fahr., and then about two pounds of flour added, and the quantity of yeast necessary, which varies considerably according to the mode of working adopted. These quantities are those commonly taken with a sack (280 lbs.) of flour. Fermentation proceeds vigorously owing to the presence of saccharine matters from the potatoes and the flour, and after a while ceases. The custom of using potato ferments is not at all universal.

What the baker calls his sponge consists of a certain proportion of his flour, water, and all of either his yeast or finished ferment as the case may be. These are mixed together in such proportions, that the sponge is slacker considerably than is the dough actually employed in making bread. Fermentation proceeds until the sponge is sufficiently ripe, or ready for the next stage of bread-making.

The next operation is that of making the dough. The sponge is taken, to it are added the remainder of the water, flour, and also the salt, and the whole thoroughly mixed. Fermentation continues, and finally the dough is considered ready for the final stage of shaping into loaves and baking.

A common method is to adopt all three processes just described, but some bakers discard the ferment, using only the sponge and dough; others use no sponge, working with ferment and dough, mixing in all the flour and water at one stage, while some work with a dough only, mixing all the materials together in one operation. These are further complicated by variations in the proportions of the materials used at each stage.

The action and reaction of flour and fermentation on each other are so intimate that it is exceedingly difficult to dissect them and consider each separately. Still, I wish to-night, so far as possible, to direct your attention to flour, and will ask you to bear in mind that the general action of yeast on flour is to soften it during fermentation. The comparatively hard and tenacious gluten is first rendered more mellow and elastic; fermentation carried too far destroys these properties, and ultimately causes the gluten to be short and rotten in texture. This point is well illustrated by subjecting pieces of dough to fermentation for different lengths of time. Thus, in the case of these three pieces, one has been only just made, the second was made some two hours ago, while the third has been standing some ten hours. Notice that the gluten of No. 2 is softer and more ductile than that of No. 1. No. 3, on the other hand, is almost non-coherent, and can scarcely be recovered at all by the ordinary process of working. Until we deal with yeast, it will be sufficient to remember that these experiments illustrate the general action of yeast on one most important constituent of the flour.

To make good bread one of the first steps is the careful selection of materials, and first and foremost among these is the choice of flour. During the past ten years enormous strides have been made by bakers in this direction. For one baker who subjected flour to any tests for quality, prior to Dr. Graham's lectures, there are now probably a hundred who do so. The result is beneficial in the highest degree, not only to the baker but to all except the black sheep of the millers and flour merchants from whom he obtains his supplies.

In dealing with this vital problem of the choice of flour for bread-making, it is necessary to lay down some fixed method of flour classification. Flour comes into the market under fancy names or brands, such as "Excelsior," "Iron Duke," and many others. Some brands are well-known, and represent definite and very constant varieties of flour; but others (and these are in the majority) are but little known, and different parcels sold under the same name are found to vary considerably in character. Again, British millers have adopted for themselves a clasification of flours according to quality, and accordingly in London we have what are known as Town Superfines, Town Whites, and Town Households. These are usually flours possessing in a large degree those properties which the baker groups together under the name of strength. From the provinces we get flours of a weaker nature, and these find their way into the London market as "Country" flour, and are also subdivided into Superfines, Whites, and Households. When first introduced, this mode of classification undoubtedly answered the purpose, but with the increased knowledge now possessed by bakers of the essentials of their trade, a better and more trustworthy classification becomes necessary. I claim that not only the scientific but the natural classification of flours is according to the wheats from which they are derived.

This brings us at once to the consideration of the whole question of whether a mixture of wheats should be made and then ground into a mixed wheat flour, or whether single varieties of wheat should be ground separately and then the flours mixed by the user. A good deal can be and has been said on both sides of this question. It is essentially one of those in which the views held are considerably modified by the position from which each individual approaches the problem. Let us first take the miller's position. The majority of British millers are advocates of what we will call mixed wheat flours; a few are conditionally in favour of the milling of single wheats, while a somewhat larger proportion express their willingness to mill wheats separately when required. There are several reasons why millers should adopt this position; first of all, our wheat supplies are of an exceedingly complex character. There is no quarter of the world which does not supply us with wheat, and the wheat from these different localities varies most remarkably in quality and properties. Say the millers, if we were to mill all these separately, it would be confusion worse confounded for the baker who has to use them. He would be so puzzled that it would be absolutely impossible for him to blend all these bewildering varieties of flour satisfactorily. Further, some varieties of wheat are so unsatisfactory in quality that a separate flour from them would be unsaleable. Another point claimed by the miller is that by watching the market, he at times has the opportunity of buying a particular parcel of wheat at a very cheap rate, and so enhances his profit by working the same off into his wheat mixture, This of course is a purely commercial element, and one which we do not here wish to discuss at length. Millers say further that some varieties of wheat are exceedingly difficult to mill in a separate condition, for example, the very hard Indian wheats on the one hand, and the very soft English wheats on the other. If these wheats are mixed and then allowed to lie for some time, each improves the milling condition of the other by equalising the moisture which they contain, thus rendering the former less brittle, and toughening the latter. But even granting that these wheats can be milled separately, the whole dressing arrangements of the mill would require alteration for each kind of wheat, thus adding enormously to the cost of the production of flour. (To the uninitiated it may be explained that "dressing" is the operation by which flour is separated, during milling, from the bran and other offal.) Such is in brief the case for the miller.

Let us next examine the position taken by the baker; and at the outset it must be admitted that there are bakers, and bakers. One class, which even at present is confessedly a very large one, has been and still is in the habit of using such flour as the miller thinks best suited to its requirements. These bakers naturally turn to the miller when in difficulty, and are largely if not entirely governed by his advice, and dependent on his knowledge. Another class of bakers is that of which each member uses his own judgment in the selection of flour, purchasing each one for the particular properties it possesses, and blending them in the manner which he deems best suited to his purpose. Wisely or unwisely, the former brings little or no independent judgment to bear on the kind of flour he uses, the latter judges for himself as to what his flour mixture must be, and is governed by his own opinion in the selection of flours, and the mode of using them. It is the more advanced bakers of this latter class who express themselves so strongly in favour of single wheat flour. Their reply to the millers' argument, is that with different varieties of wheat someone should or ought to understand their baking properties before they are used. It simply means shifting the responsibility of judgment from the shoulders of the miller who has not to use the flour on to those of the baker who has, and who ought to be far better qualified to form an opinion as to their baking merits, and how when used they are best used. If certain kinds of wheat are so low in quality that they produce an unsaleable flour until bolstered up by admixture with better qualities, then bakers should have the option granted to them of deciding whether they will lower the quality of their bread by the introduction of flour of this kind. The modern baker not only feels, but acts on the feeling, that any fluctuations in the market price of special kinds of wheat is something of which he has equal rights with the miller to seize the advantage, and accordingly does so. We come next to the miller's argument that certain kinds of wheat can only with difficulty be milled in a separate condition. The force of this is lost in the fact that the baker, as baker, has nothing to do with the difficulties of milling. It is sufficient for him to state his wants, the mode of supplying them he fairly leaves to be settled by those whose business it is to prepare flour for him. If all millers were agreed that separate wheat milling was an impossibility, separate wheat flours would have no existence, and the question would be settled. But millers are not so agreed, many of them are already producing such flours, and hence the baker has nothing to do with the problem of overcoming the difficulties of manufacture. It was, as a matter of fact, the introduction of such flours that first awakened bakers to their superiority for many purposes.

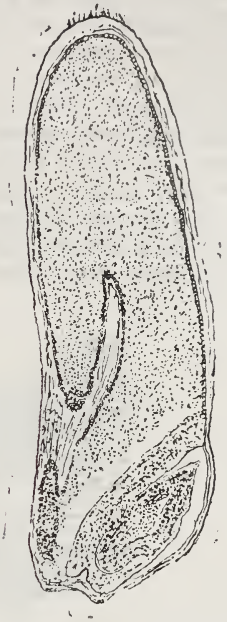
But the position practically assumed by the baker is not one fraught with insuperable difficulties to the miller. There are certain varieties of wheat which he requires to be milled separately, among these are the kinds known as Spring and Winter Americans, some kinds of Russian wheat, and English wheat. Flour from Austria-Hungary is also demanded, because of the special kind of wheat from which it is milled. There are, therefore, some half-dozen kinds of wheat which must be separately milled. Under ordinary conditions of harvest none of these present any special difficulty to the miller in their treatment. With the development of modern bread-making methods, these are a necessity to the baker, and must be obtained somehow and from somewhere. Other conditions being equal, they will be bought in preference from British millers, but if not thus obtainable the demand will be met by foreign mills. Single wheat flours from other sources will be welcomed, but no serious difficulty arises from other wheats being milled as mixtures, and sold as unclassed flours.

It will be seen that the general principle which guides the miller in manufacturing mixed wheat flours is that of selecting wheats which shall produce a flour that, without any admixture, shall be fitted for direct use by the baker. I do not for a moment contend that millers fail to attain this object; on the contrary, I wish distinctly to express my recognition of the fact that they do thus prepare very useful flours. But there is an element of uncertainty about such flours which precludes their use for many purposes of the baker; the changes from time to time in the wheat mixtures produce results on the flour that may be unperceived by the miller, but are of serious consequence to the manufacturer of bread.

I wish, in the next place, to direct your attention to the properties of flour from wheats of different descriptions, but before doing this it is necessary that I describe to you the different grades of quality in flour that can be obtained from one and the same wheat. It will assist us in this if I first point out by the aid of some diagrams, something of the physical structure of a grain of wheat.

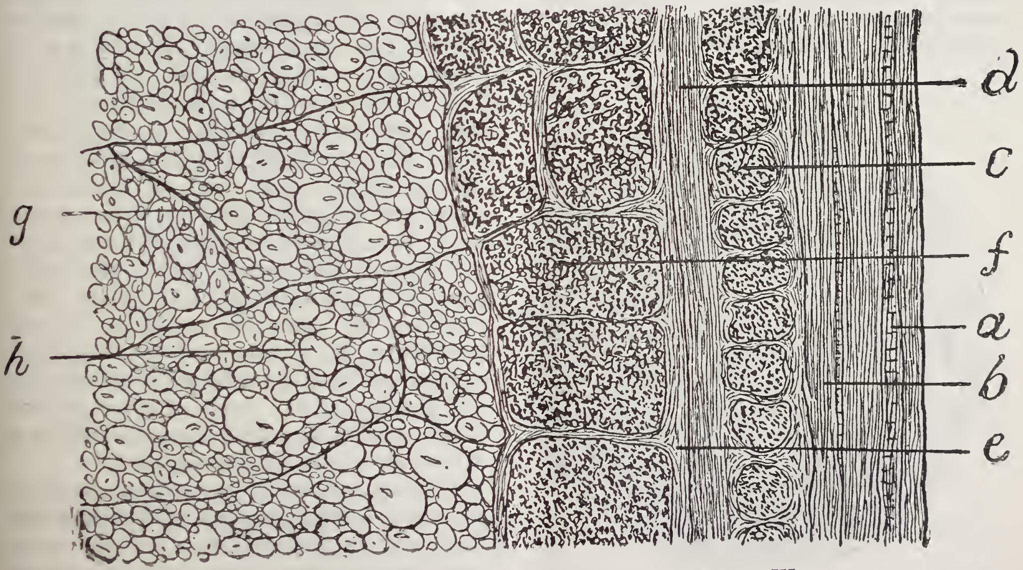
This (Fig. 1) is from a photograph of a rough microscopic sketch of a grain of wheat cut longitudinally. The greater portion of the grain is that known as the endosperm, and is the part of the wheat from which the flour is formed. At the lower end we have the germ or embryo of the grain. Enclosing the whole is the branny coating. The inside of the bran consists of a series of square cells; observe that these do not enclose the germ. Notice that to the left of the figure we have the crease of the wheat grain, which has been cut obliquely in preparing the section.

FIG. 1.



GRAIN OF WHEAT, LONGITUDINAL SECTION.

FIG. 2.

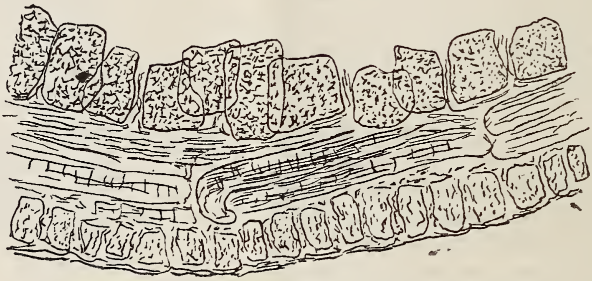


LONGITUDINAL SECTION THROUGH BRAN AND ENDOSPERM OF WHEAT.

This diagram (Fig. 2) shows a portion only of grain of wheat under a microscopic magnifying power of 440 diameters. The right-hand portion of the diagram consists entirely of the bran, which consists of a number of different layers. Of these, *a* is the outer epidermis or cuticle; closely attached to this is the epicarp, *b*. The portion marked *c* is the endocarp, and consists of a number of cells of round outline when cut longitudinally. Their length is several times their diameter, and they encircle the grain, for this reason receiving the name of "girdle" cells. Below this we have *d*, the first of the envelopes of the seed proper, termed the episperm, and containing most of the colouring matter of the bran. Underneath this is a thin membrane, *e*, which envelops the square outlined cells before noticed, and which are marked *f* in the figure. These are termed "cerealin" cells, being so called from the albuminoid of that name which they contatn. At times these are called, as a relic of older nomenclature, gluten cells. This name is a misnomer, because no gluten as at present understood is contained in these cells. So far we have been dealing entirely with the bran; we next have the endosperm. This is divided into a number of cells of comparatively large size by layers of cellulose, *g*; these in turn are filled with granules of starch, *h*, embedded in gluten. The proportion of gluten in the cells nearest the bran is higher than that in those from the interior of the grain, but the difference is not very great. Flour from the centre and exterior of the endosperm of one and the same wheat yielded on analysis respectively 6·51 and 8·60 per cent. of dry gluten. The average flour from the whole wheat yielded 8·54 per cent.

In this (Fig. 3) is shown the various cells and layers viewed at right angles to the position of the previous figure. The girdle cells are particularly noticeable.

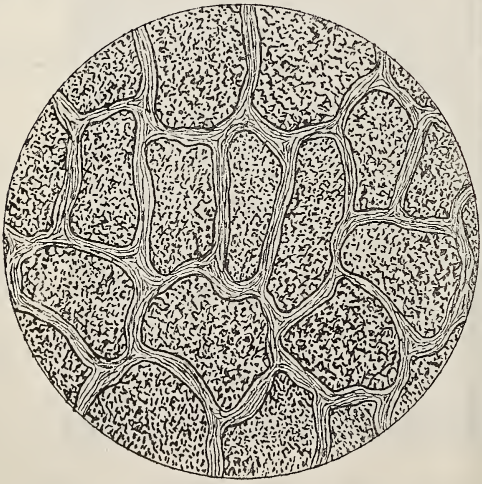
FIG. 3.



TRANSVERSE SECTION THROUGH BRAN OF WHEAT.

This (Fig. 4) consists of the inner bran layer stripped and viewed alone, showing the arrangement of the cerealin cells.

FIG. 4.



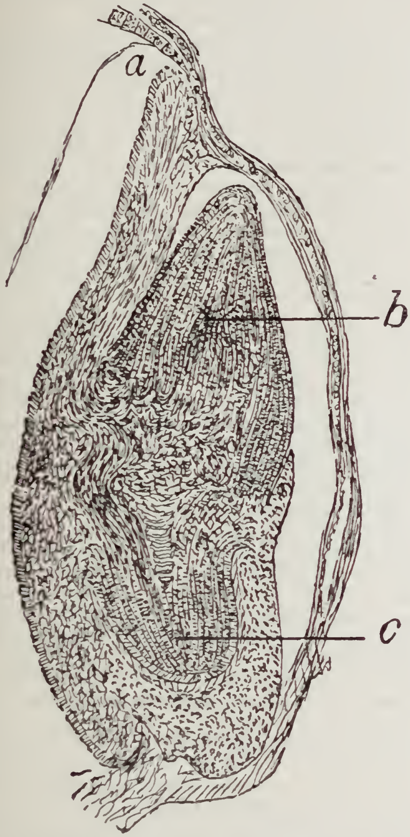
GLUTEN OR CEREALIN LAYER OF THE BRAN OF WHEAT.

Fig. 5 (p. 89), showing a most important part of the wheat grain, demands careful attention. Notice first that at *a* the cerealin cells of the bran cease. In the act of cutting the section, the layers of the bran have become detached from the germ. The part of the germ marked *b* is the "plumula" and is that from which the stem and leaves of the plant grow. From *c* the radicle or rootlet commences its growth and finds its way downwards into the earth. On the left-hand side of the figure we have a series of elongated cells, placed obliquely to the face of the germ; these constitute the *scutellum* or shield. During germination the scutellum acts by absorption, and provides from the endosperm nutriment for the growing plant. Study of these various diagrams will give a fairly comprehensive idea of the structure of the wheat-grain.

Theoretically, the miller aims at obtaining the whole of the endosperm finely ground into flour, without contamination with any other parts of the wheat—that is, referring to our longitudinal section through bran and endosperm, separating the two at the line of demarcation. Practically, this is impossible, for a portion of the flour always escapes with the bran, and a portion of the bran gets into the flour.

Prior to the advent of milling by rolls, it was very difficult to obtain more than one quality of flour from the same wheat. When the grain found its way into the eye of the millstone, it quickly got ground, by what has been aptly termed a process of "sudden death," into flour and bran of different grades of coarseness. The flour was sifted from the bran, and thus the practical separation was into flour and "offals." A distinct step in advance was that of "high grinding," in which the millstones were set further apart, and more or less of the wheat was cracked into granules of appreciable size, instead of being at once ground into flour. These granules consisted of portions of the endosperm, or flouring part of the wheat, in a very pure form, being almost entirely detached from bran. During subsequent milling operations they were removed from the rest of the product and ground into flour separately. The result was that a finer and whiter flour was thus produced. This flour was known as "patent" flour, while all flour produced directly by the action of the millstone received the expressive name of "straight" flour. This represents the earliest separation of different flours from the same wheat; previously, different qualities of flour were obtained by alterations in the kind of wheat used. With the advent of roller milling, the miller obtained far greater control over the number of grades of flour he could produce. The modern process of flour milling is essentially one of gradual reduction. The wheat is caused to pass successively through a series of rolls, varying in number from three to seven. The first of these sets of rolls are only just sufficiently near each other to crack the wheat as it passes through, they are in each case set nearer and nearer, until the finishing pair rub off the last particles of flour from the bran. Each set of rolls produces more or less flour, branny particles, and little fragments of wheat kernel. These are separated from each other between each operation of reduction by various sifting and winnowing processes. The little fragments of wheat are variously termed middlings, semolina, and dunst. The flour and middlings from each reduction are generally reserved, and the larger particles of wheat and bran go on together to the next set of rolls. The middlings are next purified from bran, germ, &c., and finally are ground into flour. The result of these multitudinous reductions and separations is that by keeping the flour from each product separate, or mixing them together, as desired, almost any number of grades of flour may thus be obtained. Many millers produce from the same wheat, or wheat mixture, some five or six qualities of flour. These are frequently named thus:—First Patent (best quality), Second Patent (second quality), First Bakers (third quality), Second Bakers (fourth quality).

FIG. 5.



LONGITUDINAL SECTION OF GERM OF WHEAT.

We are now in a position to understand the distinctions between different kinds of flour, and accordingly I ask your attention to the following tabulated statement of the composition and characteristics of flours from various wheats.

With regard to this table of flours, it is my pleasure and duty to state the fact that I am indebted for permission to use it to Messrs. Maclaren and Sons, who are the publishers of this little primer on Bread-making which was written by myself some few months ago, in which the table appears in nearly the same form.

TYPICAL FLOURS AND THEIR CHARACTERS.

Name.	Moisture.	Dry gluten.	Water absorbed. quarts per sack.	General Characteristics.
Spring American patent	12·60	13·42	71·0	Hard dry flours, containing a high proportion of very elastic gluten, which only slowly softens during fermentation. Water-absorbing power high; colour good, but white, with comparatively little yellow or bloom in the bread. Loaf very bold and of good texture; crust yellow without foxiness; will bear very hot oven. Bread tends somewhat rapidly to become hard and dry, and is comparatively flavourless. A doughing flour, but it may be used in rapid sponges, or one-third in long sponges.
Spring American bakers'	13·16	14·54	73·0	Also hard and dry, higher proportion of gluten, but usually somewhat less elastic; softens very slowly. Water absorbed rather higher than with the patent; colour dark and greyish, varies with different brands. Loaf bold but textureless, crust very foxy, catches readily in the oven. Bread harsh and dry; has, with samples of specially low grade, a strong beany flavour. Straights and bakers' grades are good sponging flours, not good doughing flours.
Canadian hard Fyfe wheat patent ...	12·90	10·8	82·0	Very much the same characteristics as the spring American patent, but has remarkably high water-absorbing capacity. A sponging and doughing flour, but neither straights nor bakers' grades from this wheat are good doughing flours.
Winter American patent	11·66	8·26	65·0	Comparatively soft flours, containing a moderate proportion of gluten, which softens more rapidly during fermentation than the preceding, but still is fairly tough and elastic. Absorb medium quantity of water. Colour is very good, white and more bloomy than the spring American. Makes a very good loaf by itself, quite of medium size, and fair texture. Good yellow crust without foxiness. Bread fairly moist and pleasant in flavour. Doughing flours all grades, but may be used for rapid sponges taken on the first turn.
Winter American bakers'	11·73	10·1	69·0	Similar on the whole to the patents in general properties. Some brands make doughs with little elasticity, but which hold up well and do not give during fermentation. Loaf not up to medium size, low, and with rather a tendency to run. Much less foxy crust than spring American of about same grade, also better colour in crumb. Flavour moderate, and usually devoid of any harshness. Bread sometimes clammy.
Californian straight grade	12·1	7·13	64·0	These are usually weak, dry flours, with comparatively little gluten. They are of good colour, full yellow, and sweet in flavour.
Kubanka (Russian)	10·90	16·06		Hard dry flour with unusually high per-centage of gluten; makes a big loaf. Colour very yellow, almost pea shade; bakes very foxy. Bread very harsh and coarse in flavour. Sponging—long sponges—not good doughing flour.
Azima (Russian) straight grade	12·36	12·70	71·5	Hard flours, with good per-centage of gluten, but soften more readily during fermentation than spring American grades, for which these flours make useful substitutes. Colour of patents good; rather more tendency to foxiness than the American. Loaf bold, but if the dough is permitted to lie, frequently shows tendency to run. Bread comparatively flavourless; in lower grades coarse in flavour. Sponging flours; the patent grade may be used, one-third in sponge and one-third in dough.
Hungarian best patent	10·82	10·48	76·0	Dry and comparatively soft flours; only medium per-centage of gluten, which is very soft but elastic. Water-absorbing power remarkably high; colour white, with a most delicate shade of bloomy yellow. Loaf not very large, but of peculiar silky texture; crust yellow, without foxiness. Bread moist and of exquisitely delicate flavour. Doughing flours, but may be used in rapid sponges taken on the first turn.

TABLE OF FLOURS.—*(Continued.)*

Name.	Moisture.	Dry gluten.	Water absorbed. quarts per sack.	General Characteristics.
Hungarian lower class patents	10·98	9·23	74·5	Flours with less gluten and lower water-absorbing power than the higher-class patents. Colour very good, but usually full yellow. Bread moist, and somewhat liable to be clammy.
No. 2 Calcutta flour...	12·60	9·68	71·5	Indian flours generally are hard flours of a ricy character. Their gluten is low in amount, and usually very deficient in elasticity. The quantity of water absorbed is high. Colour is low, except with very great milling precautions. Loaf is small and runny, devoid of texture, and foxy. Bread is harsh and beany in flavour.
Old white English wheat flour	14·00	9·82	62·0	Flours from English wheats are usually soft and damp. Vary considerably with change of climate and locality. Proportion of gluten low and devoid of much elasticity. Water-absorbing power low. Patent flours are of very good colour and bloomy; bakers' grades dark and grey. Loaf small and compact; crust of better class of flours free from foxiness. Bread is moist, and has a very sweet, nutty flavour. Doughing flours all grades; may be used alone, doughing direct.
Flour from kiln-dried Scotch wheat ...	13·80	7·94	63·0	Scotch flours are even moister and softer than those from English wheats. Like them, they are low in gluten and water-absorbing capacity. Loaf is small, bread moist, and flavour pleasant. Doughing flours all grades; may be used alone, doughing direct.

The water absorbed in quarts per sack, I must explain, has been the quantity of water that the flour absorbed in order to produce a dough of standard stiffness or viscosity, which was measured in an instrument to which I shall presently direct your attention. These figures must not be considered as an actual measure of the quantity of water each flour takes to make a sack of it into a suitable dough for the baker's use. The standard used for the purpose of these experiments was considerably slacker than the stiffness of dough used in making bread. The figures, therefore, are simply comparative.

Among these flours the Spring and Winter American kinds are valued highly. They were some of the first flours to reach the baker as single wheat flours, and are, for various purposes, of the greatest possible use to him. Russian wheat flour of the Azima type is more or less capable of being employed as a substitute for Spring American, but nevertheless is a flour differing considerably from it in character. The Canadian Hard Fyfe wheat approaches very closely in properties to that known as Spring American, and is a most valuable wheat. The Hungarian flours are specially prized for use in the manufacture of fancy bread and certain forms of pastry. Neither in American nor Hungarian flours is the average quality so good as was formerly the case. One cause of this is undoubtedly the fact that the best and most progressive millers of each country were the first to export their flours. Their efforts being met with success, others followed, sending flour made from inferior wheats to those employed by their forerunners. The result is to lower the average quality. But taking even the same brands, there is evidence that the quality has deteriorated; a market having been secured, the effort to maintain the previous high standard has been relaxed, with the natural consequence of a depreciation in the character of the flour. Good American and Hungarian flours find their way to this country, but they require to be looked for. The Winter American flours are much appreciated by bakers, not only of bread, but also of fine cakes, pastry, and biscuits. It is an open secret that our largest biscuit firms are also some of the largest buyers of this class of flours. The Californian flours are principally used for mixing purposes; they are found suitable for the manufacture of bread by aeration with sodium carbonate and acids. Little public comment is necessary on the majority of these flours beyond that contained on the table before you. The samples of flour on the table, together with the bread prepared from them, will give you some idea of their respective qualities.

I am indebted for the samples of flour which you have here to several millers, among whom I must mention Messrs. Eisdell and Soundy, of Reading, Messrs. French, of London, and Messrs. Brown and Co., of Croydon. For the loaves of bread which are here I am indebted to Mr. Clark, of the Goldstone Bread Manufactory, West Brighton.

[The samples of flour included those of different grades of quality milled from the following varieties of wheat:—Red and White English, Spring and Winter American, Indian, Russian, and Hungarian. Loaves of bread were shown, prepared from each variety of flour used separately, and also illustrating mixtures of these flours in various proportions.]

There are three varieties of flour mentioned which merit, however, more detailed examination by us. First among these are the flours from English wheats. These are characterised by their production of bread of an exceedingly sweet and pleasant flavour, and, at the same time, good colour. Used alone they do not yield a loaf sufficiently large and light to suit modern requirements, and therefore have to be blended with flour of a stronger nature. The success of English wheat-growing governs very largely that of British agriculture generally, and consequently our national prosperity. Any cause, therefore, which acts as a stimulus to home culture of wheat must be productive of great benefit to the country at large.

Let us next for a moment direct our attention to the wheats of India and Canada. Both are most important dependencies of the British Crown, and countries of the greatest interest to us. The question of Indian wheat supply has of late attracted much public notice, largely on account of the dirty state in which it reaches this country. Conferences have been held to consider this matter; the opinions of the corn merchant and miller have been given and made subjects of debate. But, so far as I know, there has been one curious omission, and that is the user of the flour. A successful market for Indian wheat is a desideratum for that country, but it seems to me that the most important question of the whole is that of the suitability of the flour from this wheat for bread-making purposes. I have not found myself able to speak very highly of Indian wheat flours. I could quote the opinions of expert bakers, whose words have the greatest possible weight among members of their own trade, who would pronounce a yet more unfavourable judgment than I have done. In the face of such opinions, I would urge as a most important matter, in the interests of Indian wheat cultivation, that those who have its success at heart should take steps to secure that such wheats are grown as produce flours of greatest service to the bakers of this country. I may be overstepping the bounds of my present functions, but I have now in my mind the names of men, members of the baking trade, who, should they be formed into a committee to report to and advise Her Majesty's Government on the baking properties of Indian wheat flours and their improvement, could render most important service to both Indian and British agriculture. Although the majority of such a committee should be bakers, it would be materially strengthened by the addition of one or two agriculturists who are familiar with the problem of the development of new species of wheat, and the acclimatisation of important varieties in new districts. The flintiness of Indian wheat causes it to be considerably damped before it is milled. When converted into flour under the most favourable conditions, it produces a flour that acts as a substitute for that of English wheat. With the addition of sufficient water to the wheat softness is obtained, but the gluten remains low and inelastic. Physically, softened Indian wheat may then replace that of English growth, but is altogether devoid of the flavour the latter possesses. My point is that those varieties of Indian wheat that now reach this country serve as substitutes for, and enter into competition with, home-grown wheats.

The point to which I particularly wish to direct attention is that, if possible, by attention to the judicious selection of seed, and the method of cultivating the wheat, an endeavour should be made to produce grain whose gluten is of a more elastic character. Further, it is extremely desirable that the wheats should possess a better flavour; they should, in fact, assimilate more closely to those obtained from America.

I wish next to refer to the wheats of Canada. Some time ago I paid a visit to that country for the purpose of inspecting its wheat-growing districts. Prior to that visit the proprietor of the *Miller* newspaper distributed samples of some magnificent wheat and flour grown in the great north-western territory of Manitoba. The analysis given in the Table was made on this flour. While in Canada, I went through Messrs. Ogilvie's mills, both in Montreal and Winnipeg, with one of the Messrs. Ogilvie, and also went with him right into the heart of the wheat-growing districts. I myself collected some forty samples of wheat and flour from farmers' barns, from elevators, and from local mills, and made analyses and baking tests on these. The results compared well with those of the samples I had previously examined. This district is at present almost unworked, but with its gradual development it will open out a most favourable field for British emigration. The future farmers of North-Western Canada will be men of our own stock, who, while benefiting themselves by the change, will also have relieved the plethora of the mother country. When this district shall have developed, and sends large supplies of wheat to England, let us see what the result will be. Flour from Canadian Hard Fyfe wheats is one of the best that can be selected for mixing with English wheat flour. What the one lacks, the other possesses. For every sack of Canadian flour of this type the British baker can add a sack of pure English wheat flour to his mixture. Imports of Canadian wheats and flour will increase rather than diminish the demand for home-grown wheat.

Some ten years ago roller milling was only just being introduced in this country, while now there are few large mills working on any other system but that of gradual reduction. Apprehensions are expressed in some quarters that the flour now being produced is inferior in nutritive qualities to that obtained from stones. But, as a matter of fact, with the same wheats there is but little alteration in the composition; what little there is may be expressed in fractions of one per cent. The principal change is that the bran and the germ are more completely kept out from the flour. This reduces the quantity of fatty matter and also the phosphates, but does not appreciably affect the proportion of proteids or flesh-formers present. The reduction even in phosphates is so extremely low as to be almost inappreciable. The great merits of roller-milled flours are that they are of better colour, and instead of being crushed into what the miller and baker term "a lifeless condition," are granular to the touch and more springy and elastic during fermentation.

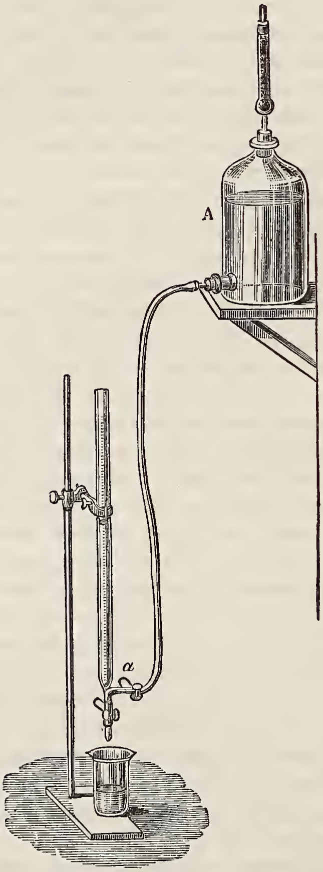
If time permitted, I should like to direct your attention somewhat more fully to the principles which govern the blending of flours. It must be clearly understood that the advocacy of milling certain wheats separately does not include that of baking the flour separately into bread. The contention is that the baker should do his own blending; one very cogent reason for this is that the two stages of sponging and doughing enable him to use different classes of flour each time. It has been already explained that some flours are naturally softer and soften more rapidly during fermentation, than others. The harder flours are reserved for the sponging stage, and include flours from Spring American, Canadian, Russian, and other hard and tough wheats. Winter American flours can be used in sponges, but with them the time must be considerably shortened. Indian wheat flours are not suitable for sponge-making, as they are devoid of elasticity. For doughing purposes the baker allows himself considerably more latitude than in the sponge. Those flours which confer colour and flavour are used at this stage: at the same time, some proportion of the harder flours is also advisable. Patents, fine Spring and Winter American, English flours, and also those from Hungary are employed in the dough.

I have, at the termination of my syllabus of this lecture, promised to direct your attention to apparatus for the commercial testing of wheat and flours, but I, at this stage, find that the time at my disposal is rapidly drawing to a close, and I shall only be able in the most cursory manner to direct your attention to apparatus having these objects in view.

Let me, first of all, point out to you that one test which is of the greatest importance to the baker is that of measuring the bread yield of the flour. This is largely governed by the proportion of water which it absorbs, and the baker naturally, from the commercial point of view, selects the flour to which he can add the larger proportion of water. The proportion of water required by the flour to make dough is the complement of the moisture which it normally contains, so that largely this rough-and-ready and direct test of the baker on the quantity of the water which his flour absorbs is a test indirectly of the quantity of water which is in it when it reaches his hands. The moister the flour he has, the less water does it take in the act of doughing. As a method of making estimates of this kind, the apparatus you see here has been devised.

It consists of an appliance known to all chemists as a burette; and in this case is graduated in quantities that represent quarts of water to the sack of flour, one and a-half ounces of the flour in question being taken for the test. The necessary quantity of flour is placed in one of these little machines to which I have already alluded as having been specially made for the purpose for me by Messrs. Werner and Pfleiderer, and the requisite quantity of water is added. There is here a means for rapidly filling this reservoir from a water reservoir placed on a shelf above. It is filled up to zero mark, and then by pinching a little spring clip you allow the water to run out of the desired point. The quantity of water being thus run in, the dough is mixed thoroughly, and this machine possesses the power of mixing with great uniformity. Having a little index attached to it, the exact number of the revolutions of the mixing blades of the machine is in that manner measured and recorded. The dough being made, the expert baker is at once able by its toughness and by its feeling to tell very closely the quantity of water the flour takes, and the character and elasticity of the dough.

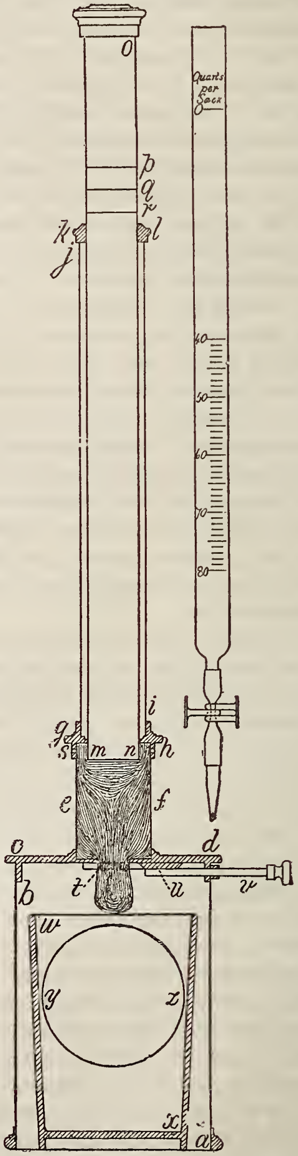
Fig. 6.



Burette Arranged with Water Reservoir.

I have here an instrument which has been devised by myself with the object of giving some means of commercially and scientifically measuring and registering the viscosity of a lump of dough, and the plan that I have adopted after a great number of experiments is this. In this little cylinder, *ef*, we place the lump of dough under examination, taking care that it is completely filled. At the bottom there

Fig. 7.



Flour Burette and Viscometer.

is a small valve, *u*, which can be easily opened, which allows the dough to escape. Above there is a weighted piston, *o m*, about 3lb. in weight. When this piston is placed in position and the valve drawn, the weight of the piston forces the dough through the aperture, *t*, and thus descends more or less quickly according to the stiffness and consequent resistance of the dough. There are a series of graduations, *p*, *r*, *r*, on the piston, and given a flour which permits this to descend at such a rate that the distance from one line to the other occupies one minute, in passing the point, *l*, all other flours which allow that piston to descend at the same rate must of necessity yield doughs of the same viscosity. When once the method of using this instrument, which I have termed a viscometer, has been learnt, it may be placed in the hands of anyone with a very small modicum of skill; and accurate results can be obtained which do not depend on judgment, but simply on the correct using of an absolute measure of the stiffness of the dough.

Want of time precludes all further reference to the question of gluten-washing, and estimation.

I will, lastly, simply refer to one point further, and that is the question of the colour of flours. The common method, known as "Pékarising," after M. Pékar, consists of pressing a slab of flour, wetting it, and allowing it to dry. A number of slabs may be served in the same way, and then their colours may be measured by comparison the one with the other. Where a registration of the colour is required, that may be obtained by an instrument known as the tintometer, the invention of Mr. Lovibond, of Salisbury, in which flour is placed on one side of the instrument, and on the other graduated sheets of glass of definite tints are introduced, so as to build up a tint which shall exactly match that of the flour. The colour of the flour being thus matched, a permanent record is obtained by registering the colour glasses by which the matching tint has been procured. After that, one of the best tests of flour is to bake it, and most of these loaves here exhibited are the result of the baking test on samples of flour. For each test 3 lbs. of flour was taken, mixed with sufficient water, and made into loaves. They were all put in the same oven side by side, and remained the same length of time, and you will be able to see the difference in appearance of each.

[The lecturer may add that the whole question of the commercial testing of wheats and flours is dealt with very fully in a work written by him on the subject of the "Chemistry of Wheat, Flour, and Bread."]

Miscellaneous.

WINE PRODUCTION IN CATANIA.

The British Vice-Consul in Catania says that the production of wine in his district has increased by one-third of the quantity that used to be produced some five years ago, and as the quantity to be yielded from recent plantations has not as yet reached its full development, it is expected that the production will still further increase. The wine so produced is partly consumed in the home markets, whilst the greater part has hitherto served for exportation abroad and to continental Italy. The preparation of these wines is not such as to suit the palate of all consumers—its taste in many cases is too bitter or too sharp—due to the primitive and irrational methods adopted in preparing and finishing the liquid, which is found to contain an excessive alcoholic strength. It is stated that the extent of land adapted to the cultivation of vines in Catania may be estimated at 30,000 hectares (75,000 acres), yielding a production of about 1,000,000 hectolitres, or 22,000,000 gallons, and it is expected that the production may be augmented by one-third, or even one-half in the course of three years. The wines better adapted for exportation are those obtained from the vines cultivated in the Bosco district or slopes of Etna, which are not used for home consumption, but are generally exported for mixing with weaker and less highly coloured wines for foreign production, and are called *vini da taglio*, or blending wines. The various alcoholic grades of wines produced in the district of Catania are as follows:—Catania (Terreforti), 15·77 degrees Centigrade; Catania (Piana), 12·02; Giarre (Piana), 13·08; Giarre (Etna), 11·06; Acireale (Bosco), 14·02; Mascalucia (Bosco), 13·95; Motta (Bosco), 15·19; Via Grande (Bosco), 13·15; and Aci St. Antonio (Bosco), 12·37. These are divided into two distinct types, called Vino del Bosco and Vino delle Terreforti. The first is a wine of a fine reddish colour, rather sharp to the palate, containing between eleven and fifteen degrees of strength, and, as previously stated, is generally exported for mixing with and finishing other wines of less strength. The second, namely, Terreforti wine, comes from the lowlands of the Piano de Catania, where the soil is of a calcareous and argillaceous nature, and its strength reaches in some places as much as 16 degrees Centigrade. These wines are of a lighter colour than the first named, and are chiefly used for home consumption, with the exception of a small quantity called *Vini bianchi Terreforti*, which are exported to the north of Europe. A vinïcultural school, under the title of Scuola Enologica, has been established in Catania for the last two years, for training young men, especially of the agricultural class, in the art of cultivating the vine and of making wines. This school is kept up at the expense of the local authorities and the State. The most important wine establishment, or *Stabilimento Enologico*, in Catania, and even in the whole of Sicily is that of Baron Antonino Spitaleri, situated at the foot of Etna, 830 feet above the level of the sea. It is well supplied with most of the implements for making wine, and possesses one hundred and fifty hectares of vineyards, the greater part of which are of French origin. It produces the so-called Etna Rosso, which is exported to America, and even to India. The district in Catania yielding the largest quantity of wine is that of Giarre and of Riposto, two picturesque towns of the province, and situated at a distance of thirty kilometres from Catania itself. The two towns are only separated by a carriage road of less than a mile in length. Giarre, with a population of 20,781 inhabitants, is a centre of great agricultural activity, whilst Riposto, with about 10,000 inhabitants, is the shipping place where the greater portion of the products of the two communes are conveyed for embarkation in an open roadstead. From Riposto in recent years a very important wine trade was carried on with France, until the year 1187, when the traffic came to a standstill in consequence of the commercial treaty between Italy and France. The preparation of spirit of wine, or alcohol, has had an important development within late years. It is extracted from wine dregs, or from the inferior quality of the wine, but the industry is so heavily taxed by Government that the most enterprising speculators find difficulty in sustaining it. Both the cultivation of the vine and the making of wine are still carried on in the old-fashioned style. The grapes as gathered are brought into what is called a *palmento*, a sort of mill, where the fruit is trodden upon by the peasants, either barefooted or generally in coarse shoes, not particularly clean, until the juice of the grapes is squeezed out into a stone tub or vat, which stands below the level of the mill or treading barn, whence the juice is transferred into casks to ripen into wine. During its fermentation, in most cases, gypsum is used as a clarifying and colouring substance, and bullock's blood and the white of egg is used to obtain a transparent and finely-coloured liquid.

Notes on Books.

DICTIONARY OF PHOTOGRAPHY. By E. J. Wall. London: Hazell, Watson & Viney, 1889.

This contains a large amount of practical information likely to be useful to photographers, especially to inexperienced photographers, arranged under alphabetical heads. For the most part the articles refer to the ordinary dry-plate methods and the usual methods of printing, though information in a shorter form is given about other applications of photography. The dictionary also contains popular explanations of many technical and scientific terms likely to be met with by the photographic students.

TEXT-BOOK OF ORGANIC CHEMISTRY. By A. Bernthsen, Ph.D. Translated by G. McGowan, Ph.D. Blackie & Son, Glasgow. 1889.

The author states that this book was produced with the view of supplying students attending his lectures on organic chemistry at the University of Heidelberg, with a text-book of moderate length and of strictly scientific character. Professor McGowan has translated it with the object of supplying a similar want in this country. The accuracy of the way in which the work has been done is vouched for by the original author, who also draws attention to the fact that a certain amount of additional matter, new since the last German edition, has been introduced.

NATURALISTIC PHOTOGRAPHY. By P. H. Emerson. London: Sampson, Low. 1890. Second edition.

The appearance of the first edition of this book gave rise to a great deal of discussion in the photographic world. The writer is well-known for his efforts to develop the artistic side of photography, by rendering photographs better suited for the company of the work of artists with the pencil and the brush. The series of views in Norfolk which Mr. Emerson has published, all of them reproduced by photo-gravure, are evidence of his right to form and express an opinion on the artistic capacities of photography, and if he is inclined to attribute to his favourite art more extensive powers than it really possesses, the mistake is one which will be readily excused. The book contains a large amount of practical information, much of it of a character which will not be found in any other of the many photographic instruction books recently published.

REVIVED GUILD ACTION.—By George Shaw. London: Simpkin and Marshall. 1889.

The actual nature of this little book is better described by its second title, "A History of the Movement for the Registration of Plumbers," since the pamphlet, entitled "Revived Guild Action," which Mr. Shaw submitted to the Plumbers' Company, in 1878, suggesting the registration of plumbers, forms but a very small portion of the book. It contains a summary of the action which has been taken by the Plumbers' Company, and which has resulted in the formation of an influential Registry of Plumbers, extending its branches over the whole of the kingdom. The documents reprinted in the appendixes give full information as to the progress of the movement.

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FRIDAY, JANUARY 3, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

JUVENILE LECTURES.

Professor Vivian B. Lewes delivered the first of his Juvenile Lectures on Wednesday, the 1st inst., the subject being "The Story of a Flame."

The Lecturer commenced by pointing out the facts which could be gleaned from everyday experience as to the nature of flame. A coal fire burns with flame for a time, but eventually becomes a red-hot mass of coke, which continues to burn without flame. Coal heated out of contact with air gives off gas which burns with flame, and coke is left which burns without flame. It is evident, therefore, that the power which coal has of burning with flame is due to the gases and vapours which it gives off on being heated, and numerous cases of the same kind all point to flame being burning gas. When substances undergo combustion in air they are found to increase in weight, whilst the air in which the combustion takes place undergoes an equivalent loss, and on examining what has taken place, it will be found that the combustible has entered into chemical combination with one of the gases present in the air, which is known as oxygen. This gas is the great supporter of combustion, and all substances which will burn in air do so with far increased brilliancy in oxygen. Chemical combination is always accompanied by change of temperature, and when this gives a considerable amount of heat, often accompanied by light, it is called combustion. From this it is seen that flame is caused by the chemical combustion of gases.

For some time it was thought that this did not apply to such flames as those of a candle or oil lamp, but it can easily be shown that in these cases the liquid oil, or the melted wax or fat, is sucked up by the capillary attraction of the wick, and is converted by the heat of the flame into gases which continue the life of the flame.

Some flames are luminous, whilst others give no light, and in the ordinary flames used for illuminating purposes the luminosity is due to small particles of incandescent carbon, while other causes, such as density or atmospheric pressure, also effect this property.

When the illuminating power of a flame is due to particles of solid matter heated to incandescence, the light given out is white or yellowish white, but the vapours of many metallic salts give distinctive colours to flame.

Professor Lewes will deliver the second lecture of the course on Wednesday next, the 8th inst., at seven p.m., when the subject of the properties of flame will be finished, and that of the products of combustion will be discussed.

LIST OF MEMBERS.

The new edition of the List of Members of the Society is now ready, and can be obtained by members on application to the Secretary.

Proceedings of the Society.

CANTOR LECTURES.

MODERN DEVELOPMENTS OF BREAD-MAKING.

By William Jago, F.C.S., F.I.C.

Lecture II.—Delivered December 2nd, 1889.

Although my previous lecture was intended to deal with the general subject of flour, it was found impossible to exclude all mention of yeast and fermentation. The action and reaction of yeast and flour on each other during panification are so interwoven, that an absolute unravelling and separation of the two is impossible. Our study for this evening is the subject of yeast, and we have the advantage of our examination of flour and various bread-making processes in the last lecture.

I must first describe to you very briefly the nature and composition of the substance called yeast, and then deal with its power of inducing the peculiar changes which are spoken of as fermentation. Again, I would refer you to Mr. Salamon's Cantor Lectures on "Yeast; its Morphology and Culture," for the fullest and most recent information on the whole subject.

The word fermentation is derived from the boiling and seething appearace characteristic of brewers' wort while being converted from the syrupy saccharine infusion of malt to the more liquid alcoholic beverage called beer. As the study of this and other phenomena was extended, it was found that not only the transformation of sugar into alcohol and other products but also a number of other chemical changes were dependent on the life and development of minute organisms. In its more modern and extended sense, fermentation may be defined as a generic term applied to the whole of this group of chemical changes. There being various kinds of fermentation, each is distinguished by the name of the principal substance produced by its action. Further, we find that for each leading type of fermentation there is a particular organism, or series of allied organisms, peculiar to it.

Thus we have alcoholic fermentation, in which sugar is changed into alcohol and carbon dioxide, with small quantities of subsidiary products. The organisms capable of producing these changes are known by the generic name of yeast. We have lactic fermentation, in which sugar is changed into lactic acid—the acid of sour milk. This change is the work of an organism named *Bacillus lactis*. Further, we have *Bacterium termo*, the ferment or organism of putrefaction; while another organism, *Bacillus subtilis*, transforms lactic into butyric acid, an acid developed in rancid butter. Now, it must not be understood that the chemical changes mentioned are the only ones each organism is capable of inducing, or that the peculiar chemical changes are produced by these organisms only. They simply represent their most characteristic and best known actions; with each organism, the changes it produces are modified by the conditions of its existence.

As the most important to the baker, let us study somewhat fully the nature and properties of yeast. This, viewed as an organism, is a plant of an exceedingly elementary structure, consisting simply of a cell somewhat in shape resembling an egg, and having a shell or wall of cellulose enclosing within a liquid consisting principally of albuminous matter dissolved in water. For their life and development all plants require food; the food of yeast is absorbed through the cell walls and there assimilated, waste products being excreted. The substances necessary for the proper nourishment and development of yeast may be classified in the following manner:—

Oxygen is obtained most readily from the quantity of that gas dissolved in water or other substances which for the time are the environment of the yeast; failing which we have *sugar*. This requires to be in the form of glucose, which is split up into alcohol, carbon dioxide, succinic acid, glycerin, and a small proportion of oxygen which the yeast absorbs. Sugar, then, may be viewed as an oxygen, supplying food for yeast. Indirectly, starch, maltose, and cane sugar may serve as yeast food, provided there are agents present capable of transforming these into glucose.

Nitrogenous Matters.—These may be obtained by the yeast from salts of ammonium, or preferably from certain nitrogenous matters, among which the peptones are particularly adapted for the purpose.

Mineral Matters.—Potassium and magnesium phosphates are the principal mineral constituents of yeast, these are contained in the mineral matter of the grain, supplying the medium in which the yeast is grown.

Let us next glance at the life history of yeast when grown in a suitable medium, such as the infusion of malt, known as wort. Taking some store yeast as obtained from the brewer at the close of his fermenting operations, we find on microscopic examination that it consists of single cells, mixed perhaps with a few pairs of cells. Each cell is seen to contain moderately dense granular matter, usually accumulated toward one side of the cell, and leaving a comparatively clear spot known as the vacuole. On placing a few of these cells in the malt wort at a temperature of about 70° to 80° Fahr., we find that they rapidly fill out and increase in size from the absorption of the the liquid in which they are placed, while at the same time the granulations became less distinct. As a next change, the round or ovoid yeast cells are seen to become elongated through the formation of a protuberance at the one end; this growth continues, and after a time constriction ensues, and a neck is formed between the growth and the cells. Still, careful examination shows that there is a free passage between the two; but as the growth proceeds, the strangulation at the neck continues, and finally shuts off the protuberance, which thus forms a new and distinct cell, still adhering to the parent one. The new cell, in its turn, is capable of again producing further cells by this process of "budding," as it is termed. Thus the multiplication of yeast cells proceeds with remarkable rapidity. In two hours, Pasteur on one occasion observed that two cells had, by budding, multiplied into eight, including the parent cells. From this it has been computed that 16,000,000 cells would have been produced in twenty-four hours. While growth and development are thus proceeding, the liquid is becoming alcoholic, carbon dioxide gas is being evolved, and the sugar disappears. If at this stage the yeast is examined, it will be found to consist of colonies of some scores of cells united together; the old cells in the centre being still distinguishable by their darker contour, while the new cells are clear, and almost transparent. As the sugar disappears, and the fermentation slackens, the cells are found to have a firmer outline, and the contents become more granular. In its old age the walls of the yeast cell become thick, and the granulations more dense. The yeast, if set aside in its moist state, decomposes somewhat quickly, and, before actual putrefaction sets in, shows very marked alterations in character; the walls, more or less, break down, and the interior protoplasm changes from its normal granular condition to a watery consistency.

Such is the history of the life and reproduction of yeast during the ordinary process of fermentation; but yeast is capable of functionising or developing under very different conditions. When exposed in a damp state to the air, as on slices of potato or moist slabs of plaster of Paris, the yeast exhibits a fungus-like growth, and assimilates atmospheric oxygen without fermentation. The yeast in this case reproduces by the formation of a group of seeds or spores within the parent cell, whose walls break down, and liberate the new cells thus formed.

This dual capacity of the yeast cell is of interest and importance. For commercial purposes yeast is required to work and function as a ferment, yet the presence of oxygen seems an essential to its vigorous growth and action. With absolute exclusion of air, fermentation can only proceed in a suitable liquid, with the employment of young and vigorous yeast cells. It proceeds slowly with old cells, while with those still older no action whatever ensues. This is not owing to the death of the yeast, because on aeration with either atmospheric air or oxygen fermentation proceeds. It is necessary to examine this matter a little more closely. Suppose that yeast is sown in a wort containing free oxygen in a state of solution. The first action of the yeast is to absorb the whole of the oxygen, during which time it may be said to be living its fungus state of existence. On the disappearance of the oxygen fermentation proceeds, and oxygen is obtained from the sugar present. It often occurs that fermentation becomes sluggish before the whole of the sugar is exhausted; if now the liquid be aerated by vigorous stirring, blowing a current of air through, or other means, the yeast avails itself of the supplied oxygen fungus fashion, and as a result gains in vigour, so that it is enabled to sustain fermentative action with renewed energy. An important result of a copious supply of air during fermentation is that much more yeast is formed in proportion to the amount of sugar consumed.

The activity of yeast depends very much on the temperature at which the fermentation is conducted; that most favourable is a temperature of from 77° to 95° Fahr. At lower temperatures the action is much slower, while at 50° Fahr., fermentation is suspended. Above 95° the action of heat weakens yeast, while at about 140° Fahr. fermentation ceases, and the yeast is destroyed.

The first action of yeast in connection with bread-making to which we will turn our attention is that of aeration. If we take a mass of dough when first made, you know perfectly well that it is dense, it occupies but little volume, and in fact would be described as heavy. But after being subject to the action of yeast for some time, it becomes light and spongy, being full of small holes; in fact, the dough is aerated. The sugar of the flour has been split up into alcohol and carbon dioxide, and this aeration is due to the carbon dioxide present. Everyone, I think, quite understands that yeast produces the action just described during bread-making, but it is important to realise that yeast not only aerates bread, but also produces other well defined and most important changes. Now let me give you an illustration with regard to this. It frequently happens in the course of bakehouse operations that a mass of dough is absolutely charged with gas, being as fully aerated as is necessary for all baking purposes. You will find with regard to that mass of dough, that the baker knocks the gas out of it by "cutting it back," as it is sometimes termed, an operation which consists in going to one end of the dough trough, cutting off a largish sized piece, turning and hammering it until most of the gas has been expelled, and doing that with all the dough he has. That operation of removing the gas from the dough is performed, not only once but sometimes even twice, on each particular sample of dough.

It would seem at first sight that if our object were simply to get this mass of dough filled with gas, so as to produce a light spongy loaf, we might as well take our dough and place it in the oven as soon as we had it aerated for the first time. But as a matter of experience, if you ask a baker his reason for performing the operation I have described, he would state that the bread if taken on first being filled with gas, would on being cooked eat "raw and cold." Those are the phrases frequently used by the baker himself in explanation of the peculiar condition which dough has when not allowed to remain under the influence of fermentation sufficiently long. Let us now glance at some of these other changes which ensue, and which the baker quite understands must occur if the bread is to reach the desired standard of perfection.

Now one of the most important points in connection with this which we shall observe is that during the process of fermentation, as I have already explained, the gluten of the flour is considerably softened. It is changed into a condition in which it is more readily digestible—possibly may more or less undergo conversion into those albuminous bodies which are known as peptones. There is some doubt as to the peptonising action of yeast, but certainly, in ordinary bread-making, there are other organisms present which are capable of effecting peptonisation. Then, again, we have what is very important, and that is, a characteristic flavour is developed by yeast. I shall have something more to say on the question of flavour a few minutes hence, more particularly in regard to variations due to the employment of different kinds of yeast; but at present I wish to point out that the flavour of bread made with yeast is different to that of bread aerated by other methods, such, for instance, as the use of tartaric acid and carbonate of soda. For these reasons we may view the aeration by yeast as being to a certain extent secondary. It is secondary in the sense that the production of carbon dioxide gas in bread may be performed by other agents, such as the one I have just instanced. But this peculiar action on gluten, and this development of the peculiar flavour due to yeast, are not attained by any other known process of bread-making. It will be understood, therefore, that the presence of yeast in bread, and its action during panification, are most important.

We next have to deal with the varieties of yeasts which are known to the baker. Among these is brewers' yeast, which, I need scarcely tell you, is one of the oldest and best known of yeasts employed by the baker. Then we have "patent" yeast, and also distillers' compressed yeast. Brewers' and distillers' yeast, I should explain to you, are two distinct kinds of yeast. I have said that yeast is a plant, and in very much the same way as you may have two distinct varieties of potatoes, which of course are plants, so we may have distinct varieties of yeast plants. These two distinct varieties are known by the names of *Saccharomyces cerevisiæ*, which is the name of brewers' yeast, and *Saccharomyces ellipsoideus*, the name of the yeast which is used and produced by the distiller. Brewers' yeast is of course obtained from beer breweries, and varies very much in quality even from the same brewery. As a matter of fact, bakers find that for their purpose brewers' yeast has of late years considerably deteriorated, and this deterioration of brewers' yeast has been contemporaneous with the use of malt substitutes instead of malt. I may just add that these malt substitutes are bodies containing a higher proportion of sugar than that yielded by malt; but, compared with malt, they are deficient in albuminoids or nitrogenous matters, and the result is that a weaker and inferior variety of yeast is produced in consequence of the employment of these substitutes. The result is that brewers' yeasts have for some time being going out of favour, and are now being largely replaced by yeasts of other kinds. I think that another reason why brewers' yeasts have acquired an unenviable reputation has been that brewers have frequently assumed that any yeast is good enough for bakers. I have found that yeast has been kept and placed aside in order to sell to the baker which the brewer would not dream of using for any purpose of his own, such as starting another fermentation; and I would suggest that if brewers wish to cultivate a sale of yeast among bakers, they should adopt no lower standard than that they would supply to the baker a yeast as good as that which they would themselves require and demand for their own use. Only those skimmings should be taken which are known to be strong and healthy, composed of pure vigorous yeast-cells. These should be properly stored in scalded clean vessels, and kept in that way until handed over to the baker for use.

Yeast as skimmed by the brewer from the surface of the wort in his fermenting vats is of a more or less syrupy consistency, and consists of the fermented wort holding in suspension yeast-cells in large numbers. To obtain the yeast in a more concentrated form, this liquid is passed through powerful filter presses from which the watery portion escapes, leaving behind a solid mass consisting almost entirely of yeast-cells. This substance is now termed "compressed" yeast; the sample before you having been prepared in this manner by Messrs. Fremlin Brothers, of Maidstone. Yeast in this form is sometimes called dried yeast, although it still contains about 80 per cent. of water, so that you see that drying does not mean by a long way getting rid of the whole of the water present in the yeast. Brewers' yeast obtained in a compressed form is much more regular than is the ordinary thin yeast, one reason of its great regularity being that the proportion of water to that of yeast is much more definite. If you buy brewers' yeast, at one time it may be so thick that it will scarcely pour from the vessel in which it is contained, while on another occasion it may be almost as thin as is water itself. In the compressed condition the proportion of water present is fairly constant. Further, one finds, when care is taken to properly filter and compress yeast, the same motives which led to it being considered worth pressing have also caused greater care to have been taken in its manufacture.

Let me just indicate, in the next place, the general properties of brewers' yeast for bread-making purposes, First of all, brewers' yeast is slow in action; it ferments nothing like so quickly as some of the other varieties to which I shall presently allude. The colour of the bread is considerably darkened by the action of brewers' yeast; the crust itself becomes much redder. These points are well illustrated by the samples of bread here placed before you, and which have been prepared in every case from the same flour, and baked in the same oven side by side for the same length of time, the only difference being that they are made with different kinds of yeast. In explanation, I ought to say with regard to these that the loaves are taken from little batches made from 3 lbs. of flour, and while the results are to a eertain extent comparable, yet, especially with regard to brewers' yeast, they do not show so well in results as would be obtained with the same yeast used with a larger quantity of flour, such as sack-batches. The particular loaf I now show you was made with brewers' yeast. You will be able to see that the bread, compared with the other, is somewhat dark in colour. It is nicely moist, smells very sweet, and I think we shall find that it is very pleasant in flavour. The next one is made from a sample of compressed brewers' yeast. I shall have something to say in a moment about the quantities of yeast in each case. This compressed brewers' yeast has made a somewhat heavy loaf, but you will find the bread to be considerably better in colour than the last. In flavour also this has a slight preference. I do not think we shall find any of that bitterness of flavour sometimes resulting from the use of ordinary brewers' yeast. To the 3 lbs. of flour we take one ounce of the compressed brewers' yeast. In the former one four ounces of the liquid yeast was employed, so that you see we are not comparing exactly the same quantities. There should have been more compressed brewers' yeast taken to have given as large a loaf as is the preceding one. On the other hand, the samples prepared from other varieties of compressed yeast are made with half an ounce of yeast to the same amount of flour. You will see from the samples to which I have just referred, that the colour of the bread prepared with brewers' yeast is sumewhat dark, and that the crust is foxy. (The term "foxy" is a baker's expression for a very red crust, resulting either from the employment of brewers' yeast or the use of certain kinds of flour.) The bread is small, well flavoured, and keeps moist.

Bakers' patent yeast is brewed somewhat similarly to beer on a small scale. So far as my experience of bakers' patent yeast goes, most of it is of very inferior quality. In some few cases, however, it yields bread of high character, but in all these instances one finds that the brewing is conducted with great care and regularity. Some bakers, in yeast manufacture, start their fermentation by the addition of some "store" yeast from a previous brewing. In other cases, the fermentation is allowed to start spontaneously, and in such instances we find in the opinion of the users of these yeasts that the product is considerably superior in quality to that which has been started fermenting by the addition of store yeast. In summarising the results of bakers' patent yeasts, I may say that they give results very similar indeed to those obtained with brewers' yeasts. The variation is greater, but the general character of the bread is the same. The yeasts themselves, in fact, are similar in each case. An interesting subdivision of bakers' patent yeasts consists of those known as Scotch flour barms. These are a division of their own, and are prepared by the fermentation of thin paste of flour. A weak wort is first prepared from malt and hops; this is then mixed with the requisite quantity of flour, and boiling water is added, the mixture being rapidly stirred, until the flour is thus scalded into a thin paste. The malt converts a considerable quantity of the starch of the flour into maltose, which changes into glucose, and this supports fermentation. One characteristic of Scotch flour barm is that lactic acid ferments are present in considerable quantities, and this presence is viewed by the Scotch bakers as a necessity. In districts where these flour barms are used, the experiment has been made of brewing the flour barms at a temperature sufficiently low to stop development of lactic acid. The result has been that the bread prepared from barms brewed in this manner has not been of such good quality as that prepared from barms in the usual way. It is interesting to note in connection with the Scotch flour barms that they are used in districts where very hard flours are employed—that is to say, flours from strong American and Russian wheats. The character of these flours leads to their being subjected to fermentation during a prolonged sponge time—in some cases that time extending to 14 hours. Now, lactic fermentation has the very remarkable property of softening and peptonising the gluten and albuminoids of the flour, and it is interesting to notice that where very hard flours are used, the baker presses into his service the action of these particular lactic ferments. Scotch bread made in districts such as these always has a distinctly acid flavour. The acid flavour is not considered detrimental, but would be looked forward to by Scotchmen as being part and parcel of the necessary true flavour of the bread. Certainly, the slight *soupçon* of acid which the Scotch bread possesses is different from the disagreeableness of the sourness which our bread in the south has when it has gone fundamentally astray through some error or defect in working.

We next have to deal with the compressed distillers' yeast. As I have said, these yeasts are largely replacing the two former. In all probability, if I were asked to mention one of the most important developments of bread-making it would be this replacement of the brewers' yeast, and its companion, the baker's patent yeast, by distillers' yeast. Like the former varieties, distillers' yeasts also differ very considerably among themselves in quality. The best kinds, however, are characterised by great regularity and keeping properties. The yeast is very rapid in action, and further than that, it is more lasting than the brewers' yeast. It does not darken the colour of the bread, nor does it cause foxiness of crust. It produces a large loaf as compared with brewers' yeast, but there is an absence of the characteristic flavour of the latter. The bread is more or less liable to become dry. At this stage we may, perhaps, just look at some of these other loaves which we have here. The one I now show you has been fermented with a sample of French yeast—this one, its companion, with a sample of Scotch distillers' yeast. In both cases we have very regular fermentation. The bread is perfectly sweet, and looks considerably better both in colour and in size of the loaves than that made from brewers' yeast. Each of these samples was fermented with half an ounce of yeast, double that quantity of brewers' yeast having been employed to the same weight of flour. The next and remaining loaf of the series is one in which a mixture of a quarter of an ounce of distillers' yeast and half an ounce of compressed brewers' yeast was made. Here we shall find the quality intermediate probably between those of the other two. The loaf is not quite so large, nor the colour quite so good, as with distillers' yeast, but still they are both superior to those of the brewers' yeast loaves. In flavour most of us would prefer this loaf to either of those prepared from distillers' yeast.

These loaves show very fairly the difference in character of the bread produced. I have also here some samples of the yeast themselves. This is a sample of Scotch distillers' yeast known as the "Balloon" yeast, and was made under Dr. Squire's patent. The next is a sample of French yeast, the brand being known as "Encore" yeast. The third is a sample of Dutch yeast from the Delft Factory. I think I may fairly say with regard to the three specimens of distillers' yeast that they represent in each case some of the best brands supplied to bakers.

It will be interesting perhaps if I describe somewhat the methods employed in the manufacture of distillers' compressed yeast. I may say with regard to it that I had the pleasure, some little time back, of visiting, at the invitation of the directors, the Delft Yeast Factory, and I spent some considerable time in inspecting the various manufacturing processes. Obviously, it would be impracticable for me to attempt to describe to you very fully the processes which were employed, but I will just give you a brief outline. The first step of fermentation, I should explain to you, is that the yeast is sown in a strong malt wort. I may assume that the whole of you know what a wort is. "Wort" is the name given by the brewer to the liquid which he obtains by infusing malt with warm water. The yeast is sown in this strong malt wort, still containing the husks and also lactic bacilli and lactic acid in considerable quantity. The wort tastes distinctly sour. The lactic bacilli practically destroy themselves by the lactic acid which they produce, and as a result of this treatment a vigorous and healthy growth of yeast is obtained, which is found during the after stages of fermentation to be pure and freed from lactic ferments. The purified yeast is next added to the main bulk of the mash, which is prepared from a mixture of rye, maize, or whatever grain may be most suitable, with malt. As fermentation proceeds, the yeast and husks rise to the top; these finally are skimmed off, and the yeast, suspended in water, is separated from the "grains," as we call them in the country, by passing over sieves. The liquid portion which runs through has a milky appearance, and consists of the yeast disseminated through the water. This is allowed to settle in large vats, and the water poured off. It is then washed by being again stirred with water, and again allowed to settle. Finally, the upper layer of the sediment of the yeast is removed and rejected, the remainder is conveyed to filter presses, and the water forced out of it, and the yeast obtained in the form in which we see it. The yeast is taken to the packing-room, and packed in boxes or other suitable receptacles, according to the form preferred upon the market.

With regard to Scotch distillers' yeast, a number of unsatisfactory attempts have been made from time to time to produce it for use in this country. In the early history of these attempts the results, as I said, were most unsatisfactory. The yeast itself contained a large proportion of dead cells, was also swarming with bacteria, and produced bread of a most inferior grade. Considerable improvements in British yeast manufacture have been made at the instance of Dr. Squire, by whom several patents were taken out in 1885 and 1886. Essentially their object was to modify the best continental methods so as to suit British Excise laws, and of these the most important point was that the yeast was grown not in a wort containing the husk or grain of the malt but in a clear wort. The English Excise laws state that the wort used for spirit distillation shall be in such a condition that its specific gravity can readily be obtained by the use of a special hydrometer. Where there is a quantity of husk floating on the surface of the liquid this becomes impracticable. Fermentation is commenced in a strong wort containing lactic acid in considerable quantities, and from this it is after a time transferred to the distillers' working wort. As the fermentation proceeds, the head is skimmed, the yeast washed and purified, and thus prepared for sale. The yeast produced ranks in quality with the best kinds of pressed yeasts imported from the Continent.

I will ask you to look, before dealing with some other points, to some diagrams which I have here, and which I can show most conveniently at this stage, taking them altogether. [The diagrams consisted of representations of different kinds of yeast as seen under the microscope.]

In following somewhat further the comparative behaviour of these different kinds of yeast, my best illustration will be to refer again to bread-making processes, and with regard to potato ferments they are generally used with brewers' and patent yeast. Potatoes act as most decided stimulants of yeast action, possibly owing to the presence of special nitrogenous matters. We find with regard to potatoes that not only can we get the stimulus by using the potato in the manner adopted by bakers—namely, by mashing the whole potato up with water—but also by the employment of a clear filtered infusion of potato water, which produces very much the same effect. I want you, therefore, to see that it is not necessarily and entirely the starch of the potato which acts as a yeast stimulant, because we get the stimulating action after the starch is removed. Owing to this stimulating action of potatoes, they help weak yeast to ferment vigorously, and to produce, comparatively speaking, a large loaf. Ferments are not suitable for use with distillers' yeast, as there is a very great liability of their turning sour. Hence, for that reason they are very rarely employed together. Ferments are indicated, as I have said in the first instance, where the yeast itself is weak, but also they are very frequently employed, and successfully so, where the flours themselves happen to be deficient in strength. With regard to a weak flour, I think you will readily understand me when I say that in order to bolster it up—to keep the loaf to the desired size—a much more vigorous fermentation is necessary than with a strong flour; that more vigorous fermentation is supplied by the use of a ferment, and flours that would make very low and small bread without the employment of potatoes in this way, produce with their use a fair sized loaf.

Sponges may be, and are, more or less employed with all yeasts. Brewers' yeast works comparatively slowly in a sponge, but, on the other hand possesses the advantage that it may be allowed to work much further than other yeasts without turning sour. Distillers' yeasts in sponges require to be worked at a low temperature, and with a comparatively small quantity of yeast. One great essential of a sponge is that it shall be taken for the doughing stage at the proper time, that is to say, when fermentation has proceeded just sufficiently far. The baker has certain signs by which he is able to judge of the degree of the readiness of a sponge. On looking at a sponge in order to decide whether or not it is "ready," the baker is governed by whether or not the sponge has fallen. If you watched a sponge during its whole life-history, you would find it gradually rising until pretty close to the top of the trough in which it was made. Then, on reaching a certain point, it seems no longer able to hold the gases which it contains; the sponge bursts, the gas escapes from it, and the sponge drops. If allowed to remain, after a time, however, more gas will be produced, the sponge will again rise and will again drop. This rising and falling of the sponge constitutes the baker's very useful guide in determining when his sponge is ready. In working with distillers' yeast, the sponge is usually taken immediately the first drop sets in. In working with brewers' yeast, sponges are frequently allowed to remain until well on the second rise, or even until the sponge has dropped the second time. However, in all these cases different bakers will allow different times, according to the method of work which they adopt, and their own individual preference. Should a sponge be taken before it is ready, you will get bread which is cramped and small—in fact, working with one and the same yeast, I should feel disposed to illustrate one kind of loaf thus obtained, by comparing it with the brewers' yeast loaf I have already shown you. It will present, to a greater or less extent, the same characteristics of small volume, and comparative foxiness of crust.

A loaf obtained from a sponge which has overworked itself, will be characterised by usually producing a large loaf—a loaf in which the crust is not merely of a good colour, but unduly pale, almost sickly in its pallor—further a loaf which usually is sour, or very closely approaches being sour.

In doughs, brewers' yeasts are frequently worked with ferment only—that is to say, a ferment is made, and the sponge stage passed over entirely. Distillers' yeast, on the other hand, is more suitable for sponge and dough. It is evident then that distillers' yeast has far more aptitude for working with flour than has brewer's yeast. I have here the result of some comparative tests made under precisely the same conditions, and with regard to them I may refer you to the very simple apparatus (Fig. 8, p. 105) with which they were made, which I have found exceedingly useful for testing different kinds of yeasts. This consists of a bottle or flask, *a*, of about 12-ounce capacity, having a cork and leading tube, *b*, *c*, which pass up into a T-piece, *e*, one end of which is fitted by means of a cork into this measured cylinder, *f*, which is graduated into cubic inches. Here we have a little stopper, *d*, consisting of a plug of glass rod, inserted in a piece of india-rubber tubing. In using this apparatus, yeast and flour, or yeast and sugar, or whatever other substances are to be subjected to fermentation, are placed in measured quantities at any desired temperature in this bottle. The bottle is then placed in a vessel of water, *g g*, kept also at the temperature at which it is wished the fermentation shall proceed. This collecting vessel, *f*, is placed in a separate basin of water, *i*, *j*. At the moment the apparatus is started the air is withdrawn at *d*, and the stopper adjusted so that the water stands at zero point on the scale. The fermentation is allowed to proceed, and as the gas produced finds its way over into the vessel, *f*, and displaces the water, one can easily read off at every 15 minutes, or other desired interval, the quantity of gas being evolved. A number of these apparatus can be started side by side, and comparative results thus obtained.

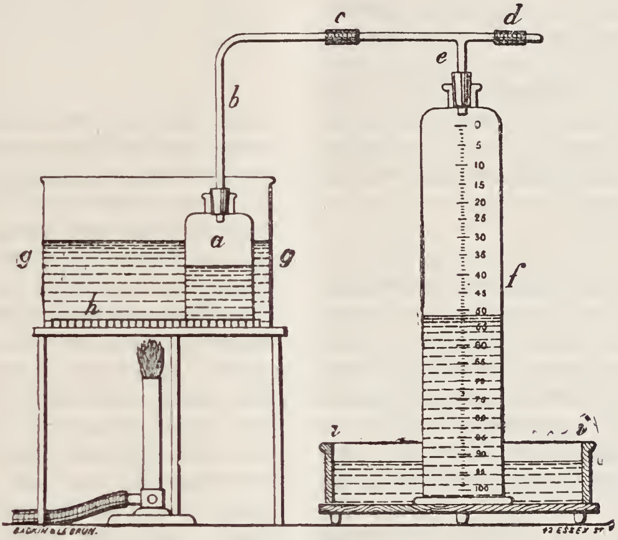
I am perfectly aware, with regard to this apparatus, that there are very many sources of error the exclusion of which is not provided for; but my object in selecting the present arrangement was to devise something sufficiently simple to be used readily by any baker, and which, from its very simplicity, can be supplied by dealers in apparatus at a low price.

I will now describe some of the results obtained by this particular apparatus. The following seven experiments were made at the same time. In the first place, particulars are given of the substances used in each experiment; following is an account of the quantity of the gas evolved in each case, readings being taken at intervals of one hour. The water-bath containing the yeast bottles was maintained throughout at a temperature of 77° F. (25° C.).

No. 1. Sugar, ½ oz.; water, 6 oz. at 77° F.; compressed English brewers' yeast, ¼ oz.

No. 2. Flour, 2·4 oz.; water, 6 oz. at 77° F.; compressed English brewers' yeast, ¼ oz.

FIG. 8.



YEAST TESTING APPARATUS.

No. 3. Flour, 2·4 oz.; sugar, ½ oz.; water, 6 oz. at 77° F.; compressed English brewers' yeast, ¼ oz.

No. 4. Sugar, ½ oz.; water, 6 oz. at 77° F.; ordinary brewers' yeast as skimmed, ¼ oz.

No. 5. Flour, 2·4 oz.; water, 6 oz. at 77° F.; ordinary brewers' yeast, ¼ oz.

No. 6. Sugar, ½ oz.; water, 6 oz. at 77° F.; French compressed yeast, ¼ oz.

No. 7. Flour, 2·4 oz.; water, 6 oz. at 77° F.; French compressed yeast, ¼ oz.

GAS EVOLVED IN CUBIC INCHES.

Time.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.	No. 7.
1 hour	4·0	0·0	0·0	3·7	0·3	3·7	3·5
2 hours	21·7	0·0	0·2	17·5	1·5	10·0	13·5
3 ,, ...	43·5	0·2	0·5	36·0	0·7	18·0	21·2
4 ,, ...	55·0	0·3	0·7	47·0	1·0	25·2	25·5
5 ,, ...	65·0	0·5	1·0	57·0	1·0	33·1	29·0
6 ,, ...	80·3	0·5	1·0	72·0	1·0	40·8	32·3

Notice that the first five of these tests were made with brewers' yeast, either in the compressed or the ordinary form. The same yeast was employed in experiments Nos. 1, 2, and 3. In No. 1, sugar was the medium selected for fermentation, and 80 cubic inches of gas were evolved in six hours. But in No. 2, where flour was employed, there was practically no gas produced, the reading at the end of six hours being only 0·5 cubic inches. I well remember, when making these tests, thinking that in some fit of absence of mind I must have altogether forgotten to add any yeast in No. 2. I therefore made duplicate tests with the same results, and accordingly knew that the quantities given were correct. In the next place, No. 3 test was made, and although the same quantity of sugar was present as in No 1, yet the addition of the flour almost entirely prevented the production of gas. We therefore must come to the conclusion, that not only is flour a medium which is not favourable to fermentation by brewers' yeast, but further, that its presence exerts a a decidedly retarding effect, as witness experiment No. 3. The tests Nos. 4 and 5 are simply confirmatory of the previous three, being made with ordinary instead of compressed brewers' yeast. In Nos. 6 and 7, compressed distillers' yeast was employed, and notice that although only about half the gas was evolved in the sugar test as in the corresponding No. 1, yet in flour more than three quarters of the sugar quantity of gas was evolved. In a very striking manner do these experiments show us the greater adaptability of distillers' yeast to the fermentation of dough.

I wish next to make some reference to another matter, which is one of the most vexing problems with which the baker has to deal. You will find that bakers frequently remark with regard to a yeast that it works well until it gets to the oven, and then fails altogether. There is no more disappointing result to a baker than to find the whole of his work go well—his ferments proceed satisfactorily, his sponges rise and fall to time; the dough looks lively and healthy when being worked, and the bread shows every promise of turning out well when it goes into the oven, yet it comes out flat, sad-looking, and altogether of very inferior quality. Consequently, this is one very frequent criticism on yeast, that it works well until it gets into the oven, and then refuses to work further. Now it cannot be that the yeast is exhausted, for if the dough is allowed to lie, or is cut back, it rises again vigorously, and if two samples are compared side by side, one will rise just as vigorously as the other. In ordinary dough fermentation, the sample which behaved very badly in the oven will go on fermenting just as well as the one which we know by experience afterwards will work well when subjected to the oven test. The two yeasts, then, cannot be distinguished in the quality of their working until they are thus "tried by fire." In connection with this the temperature of loaves during baking is matter of considerable importance, and, accordingly, I have made a number of determinations of the temperature of loaves at intervals of five minutes from the time of going into the oven, with the following results:—

	Temperature.	
Before being put in oven	24·5° C.	= 76·1° F.
After 5 minutes	35·0 „	= 95·0 „
„ 10 „	44·0 „	= 111·2 „
„ 15 „	55·0 „	= 131·0 „
„ 20 „	72·0 „	= 161·6 „
„ 25 „	87·0 „	= 188·6 „
„ 30 „	96·0 „	= 204·8 „
„ 35 „	96·0 „	= 204·8 „
„ 40 „	97·0 „	= 206·6 „
„ 45 „	97·0 „	= 206·6 „
„ 50 „	97·0 „	= 206 6 „

Now, note the remarkable and important bearing which this has on that question of the non-working of the yeast in the oven. If you have a yeast which works well at high temperature—which until we get up to temperatures of between 130° and 160°, worked vigorously and quickly—you will have active fermentation proceeding, during the time the loaf is in the oven, for some fifteen to twenty minutes. If you have, on the other hand, a yeast which works badly at high temperatures, which at some 10° or 15° lower is practically destroyed altogether, you have fermentation in the oven stopped entirely, perhaps at 10 or 12, instead of 15 or 20 minutes, and even during those 10 or 12 minutes proceeding much more slowly. Undoubtedly, the reason why some yeasts work so badly in the oven is that those yeasts are incapable of withstanding high temperatures, and I am of opinion, with regard to them that, a simple and ready means of discriminating between a vigorous yeast in the oven and yeasts which are faulty in that respect, may be made with the simple yeast-testing apparatus before described. The expenditure of a minimum of time and labour should enable the baker to discriminate between vigorous and weakly oven yeasts, and that with the absence of risk of bad batches of bread.

I am not at present in a position to give you the exact details by which the tests can probably best be made. As a matter of fact, the subject has only been worked at by me in this form for a very short time. Appended, however, are some fragmentary results I have been able to obtain.

Experiment on Yeast at 77° F. (25° C.)

Quantities taken — yeast, ¼ oz.; flour, 2·4 oz.; water, 6 oz.

No. 1.—Compressed distillers' yeast.
,, 2.—Compressed brewers' yeast, ordinary.
,, 3.— ,, ,, ,, special.
,, 4.—Thin brewers' yeast.

Gas Evolved in Cubic Inches.

Time.	No. 1.	No. 2.	No. 3.	No. 4.
1 hour......	4·0	2·0	7·0	..
2 hours	..	6·0	15·0	..
3 ,, ...	15·0	10·0	18·5	4·0
4 ,, ...	..	13·0	22·5	6·5
5 ,, ...	..	..	..	8·0
5½ ,, ...	21·0	..	..	..
7 ,, ...	22·0	..	..	..

Yeasts Nos. 1 and 4 were next tested in precisely the same manner, except that the temperature was raised to 122° F. (50° C.) The following were the results:—

Gas Evolved in Cubic Inches.

Time.	No. 1.	No. 4.
1 hour	13·0	1·0
2 hours	22·75	..
2½ ,, ...	23·15	..
3 ,, ...	Stop.	1·5

Notice how completely No. 4 ceases work at this higher temperature; while No. 1, for a time, is even more energetic in action.

In the next place a series of tests were made at 131°F. (55°C.). The quantities taken were not precisely the same as in the previous tests, but are given in detail.

No. 1. Compressed distillers' yeast, ¼ oz.; flour, 1·2 oz.; water, 6 oz.

No. 1*a*. Yeast as No. 1; sugar, ¼ oz.; water, 6 oz.

[No. 4. Thin brewers' yeast did not work with flour, at 122° F.]

No. 4*a*. Thin brewers' yeast, ¼ oz.; sugar, ¼ oz.; water, 6 oz.

No. 5. Another sample compressed distillers' yeast, ¼ oz.; flour, 1·2 oz.; water, 6 oz.

No. 5*a*. Yeast as No. 5; sugar, ¼ oz.; water, 6 oz.

Gas Evolved in Cubic Inches.

Time.	No. 1.	No. 1*a*.	No. 4*a*.	No. 5.	No. 5*a*.
15 minutes	1·0	1·25	...	2·0	2·0
30 ,, ...	4·0	5·0	...	2·75	3·0
1 hour	6·25	7·75	2·75	3·0	3·5
2 hours	6·5	8·75	4·0	3·5	5·5
3 ,, ...	7·0	10·0	5·75	...	...
4 ,, ...	Stop.	10·75	Stop.	4·0	7·5

Comparing the two samples of distillers' yeast; No. 1, it will be noticed, works more vigorously, both in flour and in sugar, than No. 5. The thin brewers' yeast, No. 4, works at this temperature in sugar; although inactive in flour and water, at a temperature lower by nine degrees. At a temperature of 140° Fahr., neither Nos. 1 nor 4 evolved any gas in a sugar solution. These results agree broadly with the general behaviour of the yeasts during baking; further investigation is, however, necessary in order to check this mode of testing against actual practical experience with the same yeasts.

I should have liked to have said one or two words about Hansen's recent researches on pure yeast cultivation, but I find again time will of necessity prevent me from going very much further. The researches themselves were described very fully indeed in that course of Cantor lectures to which I have found it necessary to refer so frequently. Hansen discovered that different varieties of yeast produce different flavored beers, and as a matter of fact he carried on his researches to a very minute extent, dividing the yeast up into several groups, and altogether discovering some eight or nine distinct varieties. We have found that the two leading varieties—*S. cerevisiæ* and *S. ellipsoideus*, with which we have to deal, show quite as distinct differences in bread-making; and it is difficult to say whether certain of the differences in flavour are due to the actual yeast or the substances with which mixed. Brewers' yeast is associated with large quantities of the liquid in which it is grown. The hops confer distinctive flavour, and further act as a bactericide, and so tend to prevent sourness. The liquid present contains invertin, hence greater diastasic power than compressed yeast, and greater moistness, due to formation of dextrin. The greater moistness is also doubtless in part due to actual size and physical condition of the loaf. After making all allowances, the balance of evidence is in favour of flavour being in part due to the yeast itself. At the Delft Factory yeast is manufactured from pure Hansen cultivations grown in the bacteriological laboratory attached to the factory. Hansen's method is employed for the purpose of obtaining yeast of a healthy and vigorous type. This object is attained by the careful selection of yeast-cells and growth from pure cultivations; but the problem of selection of different kinds of yeast for their effect on the flavour has not as yet been worked out very thoroughly or exhaustively.

Having discussed the properties of the different kinds of yeast that are employed for bakers' purposes, let us sum up those points which are *desiderata* in a perfect yeast for use in bread-making. First of all it must be portable. I am speaking of course of yeast obtained outside the bakery, prepared by a manufacturer and seller, as distinguished from any yeast the baker may himself prepare. Such yeast must be in a condition in which it can readily be transferred from place to place, preferably in a semi-solid state, and if not obtainable in that form, then in as concentrated a condition as is possible. The next essential point about yeast is that it should be pure, by which I mean that it should be free of any substances which would act to the prejudice of the yeast. Amongst these bodies which are decided impurities are such organisms as those which produce putrefaction and other detrimental changes during the time the yeast is being used. In the next place the keeping properties of the yeast should be good. Yeast at the best of times is one of those substances which keep very badly; but at any rate, care should be taken that it shall keep as long as possible. Further, the yeast should be regular in quality; and I think many bakers will agree with me that they would rather work with an inferior yeast which was regular in its inferiority than with one which averaged better results, but was inconstant and irregular in behaviour. A baker wants from day to day to be able fairly to depend on the same quantity of yeast doing the same amount of work.

In the next place, with regard to the finished article, it is necessary that the yeast should produce bread of good colour and of good flavour; and which in volume and texture should be of a fair size, not unduly small or heavy, and last, and probably as important as any of them, the yeast should be free from any tendency to produce sourness.

I pass on from this point to the question of the testing of the yeast, and one of the first tests which one applies to a sample of yeast is its microscopical examination. Now that is a thing which, unfortunately, cannot be shown to you by actual demonstration. It is impossible, in a course of lectures such as this, to place microscopes upon the table, and effectively point out to each and all the peculiarities which distinguish healthy from unhealthy yeast. I hope, however, that the wall and other diagrams of yeast that are exhibited, will have afforded you a very fair idea of what yeast looks like under the microscope, especially as four of the lantern diagrams were actually photographs, taken with the microscope itself, of the yeast as it appears on the slide. I should say first of all, with regard to examining yeast under the microscope, study the appearance of the yeast-cells themselves. That is probably the most important thing. The cells should be regular in size, they should show walls of fair thickness; on the one hand too great thickness, and on the other too great thinness, ought to be deprecated. The contents of the yeast-cell should be in a granular condition. The opposite of this granular condition is that the cells are watery in appearance, and the difference is due to something like the same cause which produces differences in the appearance of eggs. That will be a familiar illustration to many of you. Those of you who are using eggs at this time of the year know that instead of being viscous and syrupy in consistency they are frequently watery, and the analogy can be carried further, because those which are watery are spoken of by the users of eggs for confectionery purposes as being weak. This is due to the breaking down, more or less, of the albuminous matter of which the white of egg consists. The interior of the yeast-cell also contains, as I have told you, an albuminous matter, and this albuminous matter, when the cell is partly on the way to disintegration, first of all breaks down into a more watery condition, and if in this watery state it is examined very closely, some more or less solid particles can be seen floating in the liquid interior of the cell. These consist probably of the *débris* of the cell walls, and they frequently show a distinct movement of the type that is spoken of as the Brownian movement. This is a species of motion exhibited by exceedingly fine particles of matter—not necessarily living—when remaining in a suspended fluid. You can observe the Brownian movement, for instance, in a little ordinary gamboge rubbed with water; a drop of the liquid examined under the microscope shows the same kind of movement that we have in the interior of the comparatively broken-down yeast-cell. I want you not to associate this particular Brownian movement of the interior of the cell with necessarily the idea that these little particles are endowed with separate life.

In the next place, after having obtained an idea of the condition of the cells themselves, one examines the sample of yeast for the presence or absence of any foreign ferments, and amongst those foreign ferments we have that which produces lactic acid, the ferment of putrefaction, and others. Amongst these the only one under any circumstances to be tolerated is the lactic bacillus, and even with regard to this, considerable differences of opinion exist as to the advisability or otherwise of using yeast in which any great proportion of these organisms are found. This is a point which perhaps requires some little explanation. In the ordinary preparations of yeast, such as are sold to the bakers, the presence even of lactic ferments is to be condemned, and the reason for the condemnation is this. They are in themselves, so far as they go, evidence of a careless and inefficient system of working during the brewing and preparation of such yeast, and because they are evidence of this careless working they condemn the yeast itself indirectly. On the other hand, as I have already incidentally mentioned, in Scotland particularly, yeasts are prepared in which the presence of these lactic ferments is valued. It is valued in these cases, I think, because in the first place of its action on the gluten and albuminous constituents of flour generally, and also because such yeasts are used there in conjunction with flours of the type that require a very long period of fermentation, in order to mellow or soften the dough sufficiently for the production of the best bread.

So much for this question of the microscopic appearance of yeast. It is one of those things which it is difficult to lay down by actual description, because very many of the minute points of appearance by which one judges almost instinctively of a sample of yeast are scarcely capable of description. It is said sometimes that it takes a man a lifetime to learn the points of a horse, and when he has learnt them he can never thoroughly demonstrate them to anyone else. It is something in the same way here. I do not say that it takes a lifetime to learn the points of a sample of yeast, but certainly when they are learnt, it is a matter of some difficulty to explain correctly, so that another person without the same experience shall be able to form the same judgment. The only point is that the judgment must be cultivated in the same way as the other to which I have referred, by experience, and by carefully watching the different samples of yeast, comparing their appearance, and analysing the work they do in baking. It is by gradually educating oneself on these lines that the capacity to distinguish between good, bad, and indifferent samples of yeast, so far as the microscope enables one to judge, is attained.

I have come then, in the next place, to the question of the "strength" or gas-evolving power of a sample of yeast, and after all I want to point out to you that in securing yeast the baker buys gas-evolving power. An apparatus for the determination of the amount of gas which yeast evolves has already been described to you. This apparatus is useful within a certain range, but there are, after all, limits to the degree in which it can be used. So far as I have found with regard to it all tests made under the same conditions give concordant results, and a good deal of information may fortunately be obtained in that manner as to the character of the yeast. But, after all, tests of that kind require supplementing by baking tests, in order to make oneself acquainted with the power and properties of the sample under consideration. I think you will find that an examination of the fermenting properties of yeast at very high temperatures will enable you to discriminate between samples, and to perform what I think most of you will agree with me is of very considerable importance—to pick out and reject those yeasts which work badly in the oven.

I come, in the next place, to refer briefly to yeast adulteration. Now with regard to that, there is no actual line of demarcation between adulteration and admixture. Such a thing as pure yeast is unobtainable; the very act of purifying it is one which practically destroys it. Yeast, in any commercial form in which it can be obtained, is essentially and invariably mixed with either water or water and starch. It would be impossible to remove the whole of the water at least from a parcel of yeast without practically destroying that sample. A desiccated yeast can be and has been prepared, and has a certain amount of vitality after being again moistened, and can be obtained in a form in which the baker can use it; but the comparative vitality of that yeast is so low, and the difficulty of obtaining it in a workable form is so great, that, commercially speaking, yeast free from water is an impossibility. Starch is added in considerable quantity to some yeasts, in less quantity to others, and in some it is not added at all. With regard to its addition I should say, as the result of the examination of numbers of samples—not merely analytical, but as the result of watching and following them closely in the bakery, both in summer and winter—that small proportions of starch are of direct service. Those proportions should not, however, exceed 10 per cent. of the total weight. I am aware that in expressing this opinion I am expressing one in which I am slightly at variance with others who are experts in the art of manufacturing yeasts. My opinion is, however, based not so much on the exigencies of the manufacturer as on the behaviour and character of yeast when in the hands of the baker. As to what the reasons are at present, it is impossible to examine them in detail, but those yeasts containing small quantities of starch are found to stand the rough usage of transit better, and to keep longer and better in the summer time. Further, although that is purely a commercial point, the actual quantity of starch added is practically compensated by the greater cheapness of the yeast itself. I am speaking of those cases in which the limit of 10 per cent. is not exceeded, and, with regard to these, there is a point of very considerable interest which I should like to recall to your mind; that is, that the compressed yeast in the so-called pure form, such as that which is placed on the table, and which is dry enough to crumble, contains over 80 per cent. of water, and the compressed yeasts in which starch is found, as a rule, contain that substance in lieu of some of the water which would otherwise be present. Consequently, it is quite conceivable that, in buying a pound of absolutely pure yeast (I mean of so-called commercially pure yeast, consisting of yeast and water only), and a pound of mixed yeast, containing from 5 to 10 per cent. of starch, that you have actually a larger proportion of yeast cells in the mixed sample than in the pure one. The explanation is that the starched yeast is capable of being prepared in a drier condition. I wish to emphasise this point very carefully, because unjust action has been taken in several cases because of the mixture of small quantities of starch with yeast. The small quantities are not added to the prejudice, but decidedly, in my opinion, to the benefit of the consumer of yeast itself, under the ordinary and average conditions.

I have only just one word more to say on this question of yeast, and that is with regard to the question of sour bread and its causes and remedies. I am inclined to sum them up under two or three headings. The first of these is that of bad yeast, and especially weak and impure yeast. I would insist on this fact, that the weakness of a sample of yeast is at least as important an element in the production of sour bread as the presence of actual bacterial impurities. I must ask you, in connection with this, to bear in mind that, however pure a sample of yeast may be, the flour itself contains in very large quantities those organisms which produce sourness, and one finds as the result of a number of experiments that a vigorous yeast is able to keep sour fermentation in check. That is to say, given the same quantity of organisms which produce sourness in a liquid in two cases, if you add to one of these samples some pure vigorous yeast, and allow the other to remain to itself, you will find, on subjection to conditions favourable to sourness, that a much greater development of acid occurs in the latter sample than in that to which yeast has been added. Healthy yeast is a more vigorous organism than the lactic ferment and others of the same series, and in the struggle for existence it would seem that the presence of the more vigorous organism decidedly holds the others in check, and so is a preventative of sourness. At times a dealer in yeast will observe that one baker gets very good results with his yeast, and another gets very indifferent ones; further, it is no uncommon experience with the master baker to find when he comes to see his bread in the morning, that certain batches of bread are perfectly sweet; and that others, if not actually sour, are in a condition which is sometimes called yeasty—they are in an incipient condition of sourness. When that is observed one knows quite well that it cannot be the yeast which is at fault. In these cases the flour itself may be at fault; the flour may be weak and unsound, and, as I have just said to you, flour itself contains these organisms which can produce sourness; the weaker the flour, especially when prepared from unsound wheats, the greater the number of these organisms which are present, Therefore one reason frequently of sour bread is the use of flour which is unsound. I do not know of any stronger proof of this fact than that which occasionally we have when the same yeast is used in the same way in the same bakehouse to produce two qualities of bread, one from higher grades of flour, the other from lower grades, and to find that under those circumstances very frequently the higher grade of flour produces a perfectly sweet loaf of bread, while the other has a decided tendency to sourness, notwithstanding that greater care be taken with the flour of lower grade. The best remedy of course for this is obvious, and consists in the use of a better class of flour. If the inferior flour must be used, then we must search for a remedy elsewhere amongst those which I now purpose to indicate briefly to you. If you have these weak and unsound flours, their very condition is such that they do not tend to produce a large well-formed loaf, nor do they tend to produce a great number of loaves to the sack. These weak flours generally are very moist, and the baker who uses them finds that his yield has a tendency to fall off very frequently. Now, under those circumstances, the dough being slacker and moister than usual, very frequently large quantities of yeast are taken, and the dough is worked at a high temperature in order to force the loaf up by a more than usually copious evolution of gas. These very steps tend to the production of sourness in bread, for the reasons that sourness is stimulated by high as distinguished from low temperature, because while yeast and lactic ferments, for instance, can both of them work at high temperatures, yet at low temperatures the power of working of lactic acid is materially reduced. For that reason the higher temperature is deleterious.

Then we have in the next place the causes of sourness resulting from working operations, apart from the condition of the yeast and flour. With regard to these, the first is undoubtedly the lack of cleanliness in the troughs and other utensils employed in the bakehouse. These are difficult to keep in the condition of cleanliness with the avoidance of the tendency to become sour; for while the most natural method of cleaning a thing that occurs to us is to thoroughly wash it, yet baker's troughs which are continually washed get so saturated with moisture that that very condition itself is an incentive to sourness. It occurs to me, speaking with some little experience, that one of the most practical methods of keeping bakers' troughs sweet and clean is first of all to have them, as a matter of course, thoroughly scraped out at least once a day. The trough itself should be so so scraped with an ordinary dough scraper that every vestige of dough should be removed from it, and the trough should have no cracks or crevices anywhere in which little masses of dough can accumulate. Then I would suggest that these troughs should be washed once a week, and treated with an antiseptic of some kind, and the best for this purpose is either bi-sulphite of lime or a solution of sulphur*ous* acid, not sulphur*ic* acid. Sulphurous acid is distinguished by having an odour of burning sulphur in a very great degree. The trough having been well washed out, in the first place, with *boiling* water, must next be washed with the solution of either bi-sulphite of lime or sulphurous acid. Then the lid is placed on so as to keep the gaseous dioxide within the trough, and the trough is allowed to remain so for some two or three hours. At the end of that time, if the operation is done on a Saturday afternoon, the lid may be taken off, and the trough placed in a warm place, and by the time the next day has come the sulphurous acid has entirely evaporated, and the trough will be found sweet and clean. I have known several cases in which treatment of this kind has carried bakers through a hot summer season without sourness, whereas before the troughs have frequently been, if not absolutely sour, very dangerously near it. The actual sourness from want of cleanliness is of course a fault which all can get over.

We come in the next place, however, to another cause of sourness, and that is over-fermentation. In the great majority of batches which are found to be sour it is because fermentation has been allowed to proceed so far. It may proceed too far for several reasons, too much yeast may be used, or fermentation conducted at too high a temperature; or, what is also of importance, the entire batches may be allowed to ferment too long before they are taken. I think one explanation why, with over-fermentation, batches of bread go sour is this: As the sugar disappears from the dough, the action becomes slower. Estimates have been made showing that the action of yeast—certainly of some kinds of yeast—is such that in solutions containing less than 1 per cent. of sugar the alcoholic fermentation ceases. So that, if at the time a sponge is ready to be taken you let it remain too long, the alcoholic fermentation becomes very slow. A species of "fretting" goes on, but no vigorous alcoholic fermentation, owing to the comparative disappearance of the sugar; but during the time when the yeast is inactive the lactic acid ferments work on readily. In that way are produced the acids which cause the sponge itself in extreme cases to become sour. When this extreme is not reached, the growth and development of these foreign ferments readily proceeds, so that at the time when the dough is placed in the oven, and afterwards when the bread comes out again, they are present in just the condition which enables them to work vigorously, and to produce sourness in the bread after it is baked. Insufficient baking is a sort of corollary to this question of sourness occurring in the baked loaf, because unless the inside of the bread is and has been raised for a sufficiently long time to a high temperature, the germs of these acid ferments are not destroyed. As a consequence, the presence of a suitable *nidus*, such as that which sodden bread particularly is, they grow and develop after the bread has left the oven. Of course, for this evil there are many obvious remedies. You should take care to work at low temperatures, to work with not too much yeast, and to carefully watch and arrange the work so that sponges and doughs are taken when they are ready, and not allowed to lie about. I may say, in passing, that, in cases of this kind, I have found brewers' yeast to withstand sour fermentation to a much greater extent than the compressed yeast of the distillery, an action which I think is due to the presence of the essential oils and resins derived from the hops used in brewing. Certainly sponges and ferments containing an admixture of brewers' yeast can be allowed to remain about without going sour much longer than they could if they were prepared entirely from distillers' yeast in which no hops were used.

Miscellaneous.

THE TOBACCO PLANT.

After the cereals, there is perhaps no plant so extensively cultivated and utilised as the tobacco plant. It is grown and employed as a narcotic in almost every country of the world, and it has been calculated that one-fourth of the human family use it.

At the Colonial Exhibition in London the dried leaf and its preparations were shown by India and every one of our possessions, and the Paris Exhibition has supplemented this display by showing its extensive production in Europe, North and South America, Eastern Asia, the Pacific Islands, and the continent of Africa.

It is somewhat difficult to obtain trustworthy information regarding the world's trade in tobacco, because so much is used up locally in different countries. It is probable that the total area under tobacco is not far short of6,000,000 acres. For the year 1886 certain official returns are available, which show that the United States, India, and Hungary are the largest producers.

The area under tobacco in acres was in—

United States	752,520
India	641,000
Hungary and Austria	149,468
Germany	49,312
France	37,156
Algeria	20,478
Italy	12,061
Holland	3,218
	2,106,213

The consumption of tobacco in the United Kingdom is large and progressive, and the revenue derived from it last year was nearly £8,750,000. The average consumption is largest in Holland —nearly 7 lbs. per head; in the United States about 4½ lbs.; in Hungary, Denmark, Belgium, and Germany from 3 to 3¾ lbs. In the Australian Colonies it is also high—3½ lbs.; in France it is about 2 lbs., and in the United Kingdom under 1½ lbs.

The yearly production of tobacco in Cuba is about 300,000 bales, and 181,000,000 cigars are also exported. The Spaniards have hitherto monopolised the trade in cigars, alleging that parts of the soil of Cuba were alone suited to the production of Havana tobacco. This assertion is now disproved, for with good choice of seed, soil, and leaf, and skilled manufacture, Jamaica is said now to send into the market as excellent a cigar as was ever shipped from Havana, and at a far cheaper rate. In the Philippines 100,000 cwts. of tobacco are produced. The Dutch possessions in the Eastern Archipelago ship a large quantity of excellent tobacco, which is held in high repute in Europe. The imports of Sumatra tobacco in Holland now average 140,000 bales, and of Java tobacco 130,000 bales.

Although there are about fifty species of the genus *Nicotiana* known, only three or four are much cultivated for the leaf. The two principal commercial forms are by some botanists treated as varieties, and not as distinct species. These are *N. Tabacum*, the most extensively cultivated kind of plant, which may be at once recognised by its longish pink flowers and tapering oval-lanceolate sessile leaves; and *N. rustica*, which has short greenish flowers and stalked ovate, cordate leaves. The leaves are coarser and more crumpled than those of the preceding. This is popularly known as the Turkish form, but it is most probably a native of Mexico and California. *N. repanda* is not very extensively cultivated, but is said to yield some of the finest qualities of Cuban tobacco. *N. Persica* furnishes the Persian or Shiraz tobacco. *N. angustifolia*, a species found in Chili, yields a very strong tobacco.

The West Indian, Latakia, and American tobaccos are obtained from cultivated plants of *N. Tabacum*, while the Manila, Turkish, and Hun. garian are reported to be derived from *N. nistica*. In India *N. rustica* is only cultivated to a very limited extent, and chiefly in Eastern Bengal and Cachar, and the leaf is never exported to Europe. *N. Tabacum* has become an abundant weed in many parts of India. The gross annual value of the tobacco harvest in Bengal may be roughly estimated at £2,000,000 sterling, but the quantity exported is small, averaging only £13,000 in value.

Of the species, *N. macrophylla* is considered to possess the qualities that distinguish a good tobacco in the highest degree. Some of the Havana tobaccos belong to this species. Madras, where the climate is admirably suited for the growth of tobacco, stands first with regard to the development of this industry in India. Dinnigul is the great tobacco district, and cheroots are manufactured at Trichinopoli. The islands in the delta of the Godavery also yield what is called Lunk tobacco, the climate being suitable, and the plants are raised in rather poor light soil, highly manured and well watered. No better evidence could be afforded of the universal use of this plant than the extensive display which was made of it in every section of the Paris Exhibition, and although most of the cases were under seal of the Customs, yet many of the kiosks were privileged to sell, such as the Dutch, Belgian, Spanish, Mexican, &c., although the sale and manufacture is a Government monopoly in France, and licenses are only granted tu privileged people.

ECONOMIC CONDITION OF MEXICO.

The Mexican Government, say the *Economiste Français*, has recently undertaken an inquiry into the internal condition of the country. The following are some of the results obtained by the inquiry:— The population of Mexico has increased during the period comprised between the years 1880 and 1888 by 1,487,701 persons, that is to say 185,962 annually, or an average increase of 2 per cent. The revenue, which amounted in 1880 to 21,936,165 dollars, reached the figure of 32,126,508 dollars in 1888—an increase of 10,190,343 dollars. Landed property in Mexico was valued in 1880 at 366,055,052 dollars, and at 473,519,871 dollars in 1888. At the end of 1880 there were fifteen railway lines in working, with a length of 1,055 kilometres (655 miles). At the end of the year 1888 the lines numbered 47, with a total length of 8,153 kilometres (5,063 miles). In 1880, there were 16,910 kilometres (10,501 miles) of telegraph line. In 1888, the telegraph system, including the coast cables, comprised 44,612 kilometres (27,704 miles). The number of telegrams despatched by the Federal Government lines, which amounted in 1880 to 381,607, exceeded 671,000 in 1888. Postal business showed a great increase—the number of letters and newspapers carried in 1880 amounted to 5,788,182, and in 1888 to 27,390,288. From the establishment of the mint, up to the year 1888, the amount of gold coined represented a value of 112,671,000 dollars; of silver 2,194,111,828 dollars; and of copper 5,940,338 dollars, making a total of 3,312,723,266 dollars. During the economic year 1886-87, the value of the imports into the Republic was 52,252,275 dollars, and of the exports 49,191,930 dollars. As regards public instruction, the progress is very marked; the number of schools, which, in 1880, was only 8,535, rose, in 1888, to 10,726, while the number of scholars increased during the same period from 435,935 to 543,977. Finally, lighthouses have been established in the ports of Vera Cruz, Coazacoalcos, Alvarado, Frontera, Celestun, Sisal, Tampico, Campèche and Progreso in the Gulf of Mexico, and at Guaymas and Mazatlan on the Pacific.

USEFUL PLANTS IN GUATEMALA.

In a report on the trade, commerce, and industries of the Republic of Guatemala for 1888, the British Consul draws attention to the various vegetable products cultivated in the country. Coffee is described as the most important agricultural product, and from its excellent quality fetches a high price in the market. The area of land planted has possibly doubled in the last few years, and owing to failure in the last year's crop in Brazil, and the consequent rise in the value of the product, an usually large acreage of fresh land is now being planted, and greater care taken with the present estates, many old plantations being renewed and added to. It is expected that next year, or the year after, 1,000,000 quintals will be produced, bringing, exclusive of consumption, a wealth of £2,300,000 to £2,500,000 to the country. There is still a quantity of good land available for purchase. Sowing is generally done in June, and when about seven inches high the young plants are transplanted into nurseries, watered in the dry season, and protected from the sun until ready to be planted out. About 100,000 quintals of coffee are yearly consumed in the country.

Sugar stands next amongst the most important vegetable products. Cacao cultivated in Guatemala is of superior quälity, and at one time it was an important article of export, but has of late years greatly fallen off, and at the present time only about 400,000 lbs. are produced, scarcely more than is required for interior consumption. The Government are encouraging farmers to turn their attention to this branch of culture, and some new plantations have been made. The seeds have been distributed in considerable quantities in various parts of the south, the sowing has shown good results, and it is expected that the cultivation of this valuable plant will be much increased. It takes about six years from the time the seed is sown before a crop is produced, but after that period each shrub will yield one pound three times a year, and last for 100 years. There is little cost in cultivating or gathering, no machinery is required, so that though there is some time to wait before new plantations give any return the ultimate profit is considerable. A slightly earlier result may be obtained by surrounding the plantation with lime or orange trees, well preparing the land, and shading the plants with suitable trees.

A quantity of coca seed (*Erythroxylon coca*) was last year imported from Peru for distribution among the people in a suitable zone for its growth, but the result was unsatisfactory, from the bad quality of the seed, and fresh means are being taken to extend the cultivation of this plant.

Pepper and cinnamon are grown in the department of Alta Verapaz. Good seed has been imported from Ceylon, and planting is extending in that fertile district, while satisfactory results have been obtained in the department of Escuintla, where a few plantations have been made.

Rice is a very large article of consumption in the Republic, and the Government have established at San José works for perfecting machinery to separate the husk.

Good tobacco is grown, but little attention is paid to the mode of preparing it. The production is being encouraged by the gratuitous circulation of the best seed procurable from Havana, the United States, and Sumatra, and many new plantations are being made.

In spite of endeavours made to protect the rubber or caoutchouc trees, the production of rubber continues to decrease, and only in Verapaz and Peten are trees found in any quantity, while the growers show no signs of replacing those that are worn out. Holes are made in the stems to extract the sap, and alum, saltwort, or some other juice used to coagulate it. It might be made a profitable industry if proper knowledge and appliances were brought to bear. A few new plantations are being made in one or two low-lying farms; about 3,000 quintals are annually exported. The plant yielding Guatemala rubber is *Castilloa elastica*.

Amongst other products grown are maize, beans, peas, and potatoes in sufficient quantity for home consumption; sarsaparilla and vanilla grow wild on the mountains all over the country. The price of sarsaparilla has fallen greatly; there was scarcely any exported last year, and in 1887 it only reached the value of £1,621. The quality of the vanilla is good, but though it figures as an export, it is not cultivated for that purpose.

Banana planting in the east is occupying much attention as a profitable industry, some 200,000 trees being now yearly planted for the supply of the United States market. About 120,000 bunches are at present exported annually. Peruvian bark has proved a failure, and the cost of introducing the tree has been practically lost. Ramie (*Bœhmeria nivea*) was also introduced three years ago and more than 600,000 shoots were distributed, with a view to its general cultivation, but exportation of the fibre has not met with satisfactory results. Indigo works are subsiding in the country, though a few still exist in the east, and means are being taken to encourage them. Indigo was exported to the value only of £93 in 1888, though formerly a very large trade was done in it. The industry in cochineal has almost entirely disappeared; for thirty years it was the principal article of export, and now the little produced is used for native consumption, aniline dyes having ruined the trade.

Notes on Books.

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MAGNETISM AND ELECTRICITY. By A. W. Poyser, M.A. London: Longman. 1889.

This is intended as a first book on the subject, for the use of students for the South Kensington examinations and others. It is in three parts: 1. Magnetism. 2. Frictional electricity. 3. Voltaic electricity. Though there are at the end references to the principal practical applications of electricity, little is said about electric lighting, and nothing about magneto or dynamo machines. The book is fully illustrated, and is throughout a record of experiments mostly of a simple character, which the student can perform. At the end of each chapter is a series of questions on the subject-matter of the chapter.

THE ALTERNATE CURRENT TRANSFORMER. Vol. I. By Dr. J. A. Fleming, B.A., D.Sc. London: "The Electrician" Printing and Publishing Company. 1889.

The subject of this book, which is based on a series of Papers contributed by Dr. Fleming to *The Electrician*, is larger than its title indicates. It is really a treatise on the subject of electric current induction, written with the view of affording information to those engaged in the practical utilisation of periodic or alternating currents. The first volume deals with the theoretical portion of the subject, and is to be followed by a second devoted to the practical measurement of periodic currents, the construction and use of transformers, and their applications in lighting, welding, and other technical work.

A HANDBOOK OF PRECIOUS STONES. By M. D. Rothschild. New York and London: G. P. Putnam and Sons. 1890.

The author defines a precious stone as a mineral, which "must be adaptable for jewellery or ornamental purposes, and must possess beauty, hardness, and rarity," and he refuses to draw a line between stones that deserve the title of precious and those to be placed in a semi-precious or lower category. He writes, "All precious minerals used for ornamental purposes, from the diamond to quartz or chalcedony, may properly be termed precious stones." The various stones are dealt with separately, and full information respecting the composition, properties, and specific gravity of each is given. The physical characters and optical properties of precious stones are discussed at the beginning of this little book, and at the end is a table of hardness and specific gravity.

FLOWER PAINTING FOR BEGINNERS. By Ethel Nisbet. (Vere Foster's Water-Colour Series.) London: Blackie and Son.

This volume consists of twelve coloured studies of flowers (daisies, poppies, pansies, dahlias, sweet peas, roses, clematis, geraniums, &c.), with an outline sketch of each, and instructions for drawing and for painting.

MARINE PAINTING. By Edward Duncan. London: Blackie and Son.

BRITISH LANDSCAPE AND COAST SCENERY. By Edward Duncan. London: Blackie and Son.

These two volumes belong to Vere Foster's Advanced Water-Colour Series, and they contain *fac-similes* of original water-colour drawings by Duncan, reproductions of works by Turner, as well as drawings in outline, intended for the pupil to copy with all the exactness he is capable of before proceeding to the colouring. Full instructions are given for this purpose.

General Notes.

SILK EXHIBITION, 1891.—It has been decided by the Council and Exhibition Committee of the Silk Association of Great Britain and Ireland that the Exhibition of Silk Manufactures, which it was proposed to hold in London in 1890, shall be postponed until the spring of 1891.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

JANUARY 15.—Adjourned discussion on SIR ROBERT RAWLINSON'S paper on "London Sewage."

JANUARY 22.—R. BRUDENELL CARTER, F.R.C.S. Vice-President of the Society, "Vision-testing for Practical Purposes."

JANUARY 29.—GILBERT REDGRAVE, "The Utilisation of Blast-furnace Slag."

FEBRUARY 5.—ARTHUR PAGET, "High-speed Knitting and Weaving without Weft."

FEBRUARY 12.—GEORGE FINDLAY, General Manager London and North-Western Railway, "Modern Improvements in Facilities for Railway Travelling."

SIR DOUGLAS GALTON, K.C.B., D.C.L., F.R.S., Vice-President of the Society, "The Chemin de Fer Glissant, or Sliding Railway."

G. N. HOOPER, "Carriage Building and Street Traffic in England and France."

J. S. KELTIE, "Commercial Geography."

J. TRIPPLIN, "Recent Progress in British Watch and Clock Making."

ARTHUR MONTEFIORE, "The English in Florida."

Professor SILVANUS P. THOMPSON, "The Organisation of Secondary and Technical Education in London."

FOREIGN AND COLONIAL SECTION.

Tuesday afternoons, at Five o'clock:—

JANUARY 21.—JOHN LOUDOUN SHAND, "The Tea, Coffee, and Cocoa Industries of Ceylon."

FEBRUARY 18.—J. HENNIKER HEATON, M.P., "Ocean Penny Postage and Cheap Telegraph Communication between England and all Parts of the Empire and America."

MARCH 18.—A. LASENBY LIBERTY, "The Industrial Arts of Japan."

C. G. WARNFORD LOCK, "Gold Mining in Hungary."

INDIAN SECTION.

Friday afternoons, at Five o'clock:—

JANUARY 17.—F. C. DANVERS, Registrar and Superintendent of Records, "The India-office Records."

A brief account of the results of an examination, during the last six years, of the records relating to India and the East India Company, now in the possession of the Secretary of State for India.

Sir J. Theodore Hope, K.C.S.I., "The Rationale of Indian Railways."

Applied Art Section.

Tuesday evenings, at Eight o'clock:—

January 28.—Edward C. Robins, F.S.A., "The Relation of the Fine Arts to the Applied Arts."

February 11.—W. R. Lethaby, "Cast Iron and its Treatment for Artistic Purposes."

March 4.—James Orrock, R.I., "The Claims of the British School of Painting to a thorough representation in the National Gallery."

[Pictures by illustrious English masters whose works are not included in the National Gallery will be exhibited by Mr. Orrock.]

March 25.—H. Arthur Kennedy, "Glass Painting."

April 15.—C. Purdon Clarke, C.I.E., "Modern Indian Art."

May 13.—Prof. W. C. Roberts-Austen, F.R.S., "The Use of Alloys in Art Metal-work."

Cantor Lectures.

Monday evenings, at Eight o'clock:—

Prof. Silvanus P. Thompson, "The Electromagnet." Four Lectures.

Lecture I.—January 20.—*Historical.*—Generalities about uses and forms of electromagnets. The magnetic properties of iron: induction; permeability; hysteresis.

Lecture II.—January 27.—*Principle of the Magnetic Circuit.*—Experimental data. Predetermination of iron and copper for given traction.

Lecture III.—February 3.—*Special Designs.*—Various forms and their uses. Electromagnets for quickest action; for longest range; for maximum traction; for minimum weight; for alternate currents; for series work; for parallel work.

Lecture IV.—February 10.—*Electromagnetic Mechanism.*—Range of various forms. Plunger and coil. Equalizers. Modes of preventing sparks.

Thomas Bolas, F.C.S., "Stereotyping." Three Lectures.
February 17, 24; March 3.

Prof. A. H. Church, "Some Considerations concerning Colour and Colouring." Three Lectures.
March 17, 24, 31.

Richard Bannister, "Sugar, Tea, Coffee, and Cocoa, their Origin, Preparation, and Uses." Four Lectures.
April 28; May 5, 12, 19.

MEETINGS FOR THE ENSUING WEEK.

Monday, Jan. 6...Chemical Industry (London Section), Burlington-house, W., 8 p.m. 1. Mr. C. T. Kingzett, "Peroxide of Hydrogen: its Preservation and Commercial Uses." 2. Mr. Lovibond, "An Analytical Tintometer."

Medical, 11, Chandos-street, W., 8½ p.m.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. Rev. F. A. Walker, "Iceland."

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. Louis Fagan, "Egyptian and Assyrian Marbles in the British Museum."

Tuesday, Jan. 7...Royal Institution, Albemarle-street, W., 3 p.m. (Juvenile Lecture.) Prof. A. W. Rücker, "Electricity." (Lecture III.)

Pathological, 53, Berners-street, Oxford-street, W., 8½ p.m.

Wednesday, Jan. 8...SOCIETY OF ARTS, John-street, Adelphi, W.C., 7 p.m. (Juvenile Lecture.) Prof. Vivian Lewes, "The Story of a Flame." (Lecture II.)

Geological, Burlington-house, W., 8 p.m. 1. Mr. A. Smith Woodward, "Some British Jurassic Fish Remains referable to the genera *Eurycormus* and *Hypsocormus*." 2. Prof. C. Lloyd Morgan, "The Pebidian Volcanic Series of St. Davids." 3. Messrs. Grenville A. J. Cole and J. W. Gregory, "The Variolitic Rocks of Mont Genèvra."

Graphic, University College, W.C., 8 p m.

Microscopical, King's College, W.C., 8 p.m. Mr. A. D. Michael, "The Variations of the Female Reproductive Organs, especially the Vestibule in differhnt species of *Uropoda*."

Cymmrodorion, 27, Chancery-lane, W.C., 8 p.m, Mr. Joseph Jacobs, "James Howell and the Familiar Letters."

Archæological Association, 32, Sackville-street, W., 8 p.m.

Royal Literary Fund, Adelphi-terrace, W.C., 3 p.m.

Patent Agents, 19, Southampton-buildings, W.C., 7 p.m. 1. Discussion on Mr. E. Carpmael's paper, "American Interferences." 2. Discussion on Mr. Hardingham's paper, "The Working of French Patents." 3. Mr. C. M. Owen, "Certain Features of Joint Proprietorship in Patents."

Civil and Mechanical Engineers, Westminster Palace Hotel, S.W., 7 p.m. 1. Annual General Meeting. 2. Mr. H. H. Parkinson, "Notes on Prices for Labour and Materials in India."

Thursday, Jan. 9...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 6 p.m. Prof. A. H. Green, "The Birth and Growth of Worlds."

Royal Institution, Albemarle-street, W., 3 p.m. (Juvenile Lecture.) Prof. A. W. Rücker, "Electricity." (Lecture IV.)

Telegraph Engineers and Electricians, 25, Great George-street, S.W., 8 p.m.

Mathematical, 22, Albemarle-street, W., 8 p.m.

Friday, Jan. 10...Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. Alfred Chatterton, "The Irrigation Works on the Cauvery Delta."

Astronomical, Burlington-house, W., 8 p.m.

Quekett Microscopical Club, University College, W.C., 8 p.m.

Clinical, 53, Berners-street, W., 8½ p.m.

Saturday, Jan. 11...Botanic, Inner Circle, Regent's-park, N.W., 3¾ p m.

Journal of the Society of Arts.

No. 1,938. Vol. XXXVIII.

FRIDAY, JANUARY 10, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

JUVENILE LECTURES.

On Wednesday evening, 8th inst., Prof. Vivian Lewes delivered the second and concluding lecture on "The Story of a Flame."

After giving a short *resumé* of the principal points in the previous lecture, the Lecturer went on to show that in all our ordinary illuminating flames the luminosity was due to the presence of solid particles heated to incandescence, and that the amount of light given by such flames depended upon the temperature, the density of the products of combustion, and the atmospheric pressure.

If sufficient air is driven into a flame to consume all the carbon particles at the moment of their liberation, then the flame becomes non-luminous, and this principle is used in the construction of atmospheric burners, in which the non-luminosity and freedom from soot is obtained by mixing air with the gas before it is burnt; a result obtained partly by the burning up of the carbon, and partly by the cooling and diluting effect of the nitrogen from the introduced air.

If, on the other hand, there is not enough air present to supply the burning gas with sufficient oxygen for the final combustion of the liberated carbon, a very smoky flame is produced, which gives very little light, and the addition of more oxygen or air to this causes the smoke to disappear, and produces a much more intense light.

When the luminosity of a flame is due to particles of incandescent solids in it, such flames give a white, or yellowish-white light, but many colours look very different when seen by gas or candle-light and day-light, and this is caused by white light being built up of a number of rays of coloured light, and the colour of any object is due to its absorbing some of these rays, and reflecting others back to the eye, the colour we see being the colour of the reflected rays, and as the gas-light and candle-light do not contain all the rays which day-light does, in some cases the object does not reflect back the same rays in the one case as in the other. When a more luminous flame vaporises a metallic salt, the vapour of the metal often imparts to it a distinctive colour, and as the flame, in some cases, emits light, consisting of only one kind of ray, coloured objects exposed to such light appear black, unless they are of the same colour as the ray itself.

As all flame is the manifestation of chemical combination between gases, it is evident that during the life of the flame new compounds are being formed. In all our ordinary flames, whether burnt as fuel or for illuminating purposes, the chief constituents of the combustible gases are the elements carbon and hydrogen, whilst in all cases the supporter of combustion is the oxygen derived from the air, and when the combustion takes place it is the union of the hydrogen with the oxygen forming the compound "water"—and the union of the carbon and the oxygen forming a gas called "carbon-dioxide," or "carbonic acid gas," which gives the heat of the flame. The water so found is dissipated in the air in the form of vapour, which condenses to water once more if it comes in contact with any cold surface, whilst the carbon-dioxide mingles with the air, and if it is allowed to increase in quantity in a confined space gradually renders the air unfit to breathe, and it is for this reason that the air in a badly-ventilated room, where many gas-burners or even candles are burning, rapidly becomes oppressive and injurious in its action upon health.

When flames containing carbon are checked or cooled by bringing them in contact with cold surfaces, as when gas burners are used for cooking or heating purposes, then some of the carbon is unable to obtain sufficient oxygen to form carbon dioxide, and carbon monoxide gas is produced, which only contains half as much oxygen, and this gas is a violent poison, causing many fatal accidents when present in the air in even small quantities.

In conclusion, the Lecturer said that in these two lectures he had been able only to give a small fraction of this wonderful "Story of a Flame," and that had all the points suggested by it been followed up and explored, not two but two hundred lectures would have been necessary to do it full justice. However, two lectures were quite enough to illustrate the point he wished to impress upon his little auditors, and that was, the wonder and the beauty of the ordinary actions going on around us in Nature—actions which, if they would only keep their eyes open and their minds active, would teach them truths that would enable them not only to enjoy their own lives far more than they otherwise would, but also would give them the power of adding their share to the advancement of the world's knowledge.

The CHAIRMAN (Mr. W. Anderson) proposed a hearty vote of thanks to Professor Lewes for his interesting lectures, which was carried unanimously.

ADDITIONAL LECTURES.

An additional course of lectures, on the subject of "Design Applied to Wood-carving," will be delivered by Mr. LEWIS F. DAY, on Thursday evenings, the 1st, 8th, and 15th of May.

Proceedings of the Society.

CANTOR LECTURES.

MODERN DEVELOPMENTS OF BREAD-MAKING.

By WILLIAM JAGO, F.C.S., F.I.C.

Lecture III.—Delivered December 9, 1889.

The last ten years have seen great changes in the conditions under which the manufacture of bread is conducted. The growth of population naturally demands an increase in the facilities for bread production; but of late years not only have new bakehouses been erected and existing ones enlarged, but there have also been radical changes in their construction and design. The tendency has been to the building of larger establishments than as formerly the rule. This naturally follows from the fact that the men whose businesses have been growing will be those requiring new premises, while those doing a declining trade will not be induced to expend capital on new bakeries. The system of baking bread in large factories rather than in small bakehouses has of late made steady advances. Where any manufacture is carried on on the large scale, greater economy of production is possible, though not always attained. On the other hand, the small bakery brings the man who is above all interested in the success of the place most intimately in contact with the work, and so an advantage accrues to the small baker from the very fact of the possibility of every operation being conducted under his most minute surveillance.

The law of the survival of the fittest will, in the long run, decide which system is best adapted to the satisfaction of the requirements of the public. Meanwhile, the public may rest assured that, while they give a fair price for their bread, there is no difficulty in the same being supplied under satisfactory hygienic conditions, whether from the factory of fifty ovens or the smaller bakery of one or two.

Let us glance at the requirements in a bakehouse—and these apply equally whatever the magnitude of the concern. In even the most elementary bakehouse the following are required:—

Flour store-room.
Bakehouse proper.
Bread-cooling and store-room.

The first of these is usually and conveniently an upper room of the building used as a bakery, although at times the flour is stored in the bakery itself; the second is too frequently, owing to the value of space in cities, an underground structure; the third consists of either a separate room or the shop in which the bread is sold.

I should like at this stage to describe what is my own idea of what a perfect bakehouse should be. Having this before us, it will be possible to make such allowances as are necessary in order to meet the practical difficulties arising in making the actual conform to the ideal. First of all, we have the question of situation; this should be some open spot in which there is an abundance of fresh air. For this reason the suburbs of a town are indicated, rather than crowded central sites, as the places whereon bakeries should be built. I assume here, of course, that perfect freedom of choice exists, and need not tell you that oftentimes this most desirable advantage is unattainable. Our ideal bakery will be plainly and solidly built, and will consist of at least two or three storeys, according to the space at the builder's disposal and the extent of his requirements. The uppermost floor or floors will consist of store-rooms for flour, and also sugar, fruit, and other materials employed in the manufacture of pastry and cakes. When the baker manufactures his own yeast, or prepares potato ferments, a room for this purpose will be set aside on this level; the operations of flour mixing will also be conducted here. Rooms for flour storage may have either wooden or concrete floors; of these the former have the great advantage of porosity, and flour stored on wood rarely "sweats" while kept. On stone or concrete floors the moisture evaporated by the flour while drying condenses and wets the bottom of the sacks, thus tending to render the flour musty. On such floors it is well to lay old sacks underneath the flour, thus providing a layer permeable to air between the flour and the floor. The yeast or ferment room should be paved with concrete, and must be water-tight, so that it may be washed out without danger of leakage through the floor. Below this we have the kneading, loaf-making, and baking departments; these may be either on the same or two separate floors, according to the exigencies of circumstances. Should the latter alternative be adopted, the kneading machinery is placed on the floor above, and the dough, when made, discharged through shoots into the rooms below. We then come to the baking room, or the bakery proper. Here the dough is weighed off into pieces the right size for each loaf, "moulded" or shaped, and finally baked. From the ovens the bread is taken into the cooling room, which may either be on the same level or below the bakery. Such is a general sketch of bakehouse arrangements, which naturally will be modified according to circumstances in each particular case.

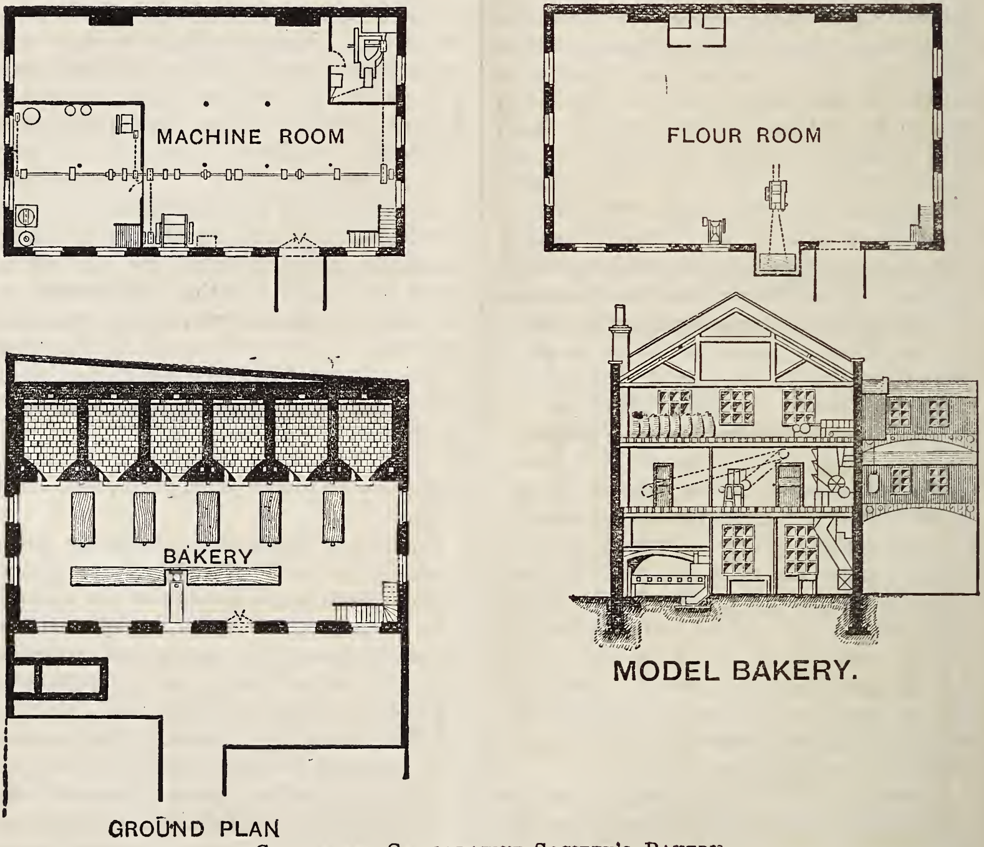
A bakery should be so arranged that the temperature is equable and not liable to sudden changes. For this reason it is well to have another storey above it. Large bakehouses covered in with span roofs and skylights are very difficult to keep warm in winter and cool in summer.

Next, abundant provision must be made for ventilation. This requires some little thought, as draughts must not be permitted. The ventilation of underground bakehouses is a matter of some difficulty, but the only condition on which their existence should be tolerated is that good ventilation and sanitation are secured. The heat of the oven and of the burners used for lighting purposes ought to afford sufficient means to ventilate the bakery. In the higher parts, near the ceiling or floor-joists, ventilators should be fixed, and these should not merely open into a yard or other space above, but should be connected if possible with an uptake shaft, such as an unused chimney of sufficient height to induce a current of air. There should also be provided inlets for fresh air, and even underground there should be no difficulty in fixing these. An air trunk large enough to admit a sensible quantity of air should lead from some open space into the bakehouse, near the floor; from this pipes should be conveyed around to suitable places for opening. These openings should be at the end of upright pieces of pipe, and must be so arranged as to admit all requisite fresh air without draught. Even with underground bakehouses, ventilation is possible if the effort be made to accomplish it. Thus in one bakehouse with which I am acquainted, the proprietor has arranged a series of pipes immediately under the ceiling, the open ends of which are placed over the oven mouths, and the others connecting with a main trunk pipe leading to an exhaust fan driven by the steam-engine. The vitiated hot air is thus being continually removed, and its place supplied by the entrance of an adequate supply of fresh air. In this case, though the bakehouse happens to be of low pitch, good ventilation is secured.

Next, waste water-pipes should be carried outside of the building, and open over trapped drains. Such pipes should contain no lodgment for accumulations of corrupt material. If the bakehouse be underground, and open drains are impracticable, such pipes should be trapped by a bend, and open into a chamber to which a ventilator is fixed, the exit sewage pipe from this chamber again being trapped. The floor and walls of any underground bakehouse should be rendered absolutely impermeable to damp finding its way through from the ground surrounding. It is absolutely essential that a bakehouse should be perfectly clean, and yet a bakehouse is the most difficult place to keep so. In a mill dry flour can easily be swept up and removed, but wet flour forms a most sticky and disagreeable mass which puzzles most bakers very much indeed to find some adequate method of thoroughly removing, and if this wet flour remains about it begins to putrefy. Probably one of the best methods of working is to brush up as thoroughly as possible in the dry state all flour scattered about, and then at times, when there is no traffic going on in the bakehouse, to thoroughly wash it, and arrange so that it may become dry before again being used. Of course Saturday is indicated as being the best day for such operations as these. One reason against continually swilling a bakehouse with water is that, especially with an ordinary brick floor, there is a great absorption of water. With the warmth this evaporates, and the damp atmosphere thus caused renders the place unhealthy for workmen. One point indicated here is that the bakehouse floor should be constructed of some non-absorptive material. Of course no crevices should exist where dough can accumulate in any part of the bakery.

At this stage I think I can proceed better if I show you, by aid of the lantern, some diagrams which I have had prepared, and I may say that I am indebted for these to one or two of the leading bakery engineers. I may mention especially Messrs. Joseph Baker and Sons, and Messrs. Werner and Pfleiderer.

FIG. 9.



GLOUCESTER CO-OPERATIVE SOCIETY'S BAKERY.

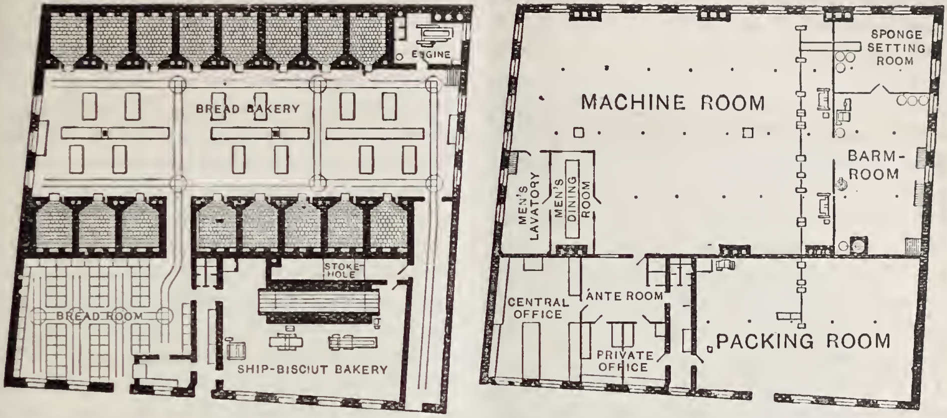
The first is a model bakery erected for the Gloucester Co-operative Society. The moulding tables and ovens are at one end. Above this, on the next stage, is the kneading room, in which are erected kneading machines, and several other machines and appliances, and above that is the flour room. The flour passes down through a sifting apparatus to the machine, and the dough is discharged into a box for the purpose of kneading, and thus finds its way into the oven.

The next diagram (p. 121) shows a ship's biscuit and bread factory, erected for Mr. Magnus of Bergen, in Norway. On the ground floor on one side is a continuous oven for ship's biscuits, and on the other side are the ovens for the bread. There is a store room, in which both bread and biscuits are brought for cooling. Above is the machine room, and the room for preparing yeast and ferments. There is a sponge setting room adjoining, and other offices, and over this would be the flour room.

Another diagram (Fig. 11) shows Mr. W. G. Cox's bread and biscuit factory at Goulbourn, New South Wales.

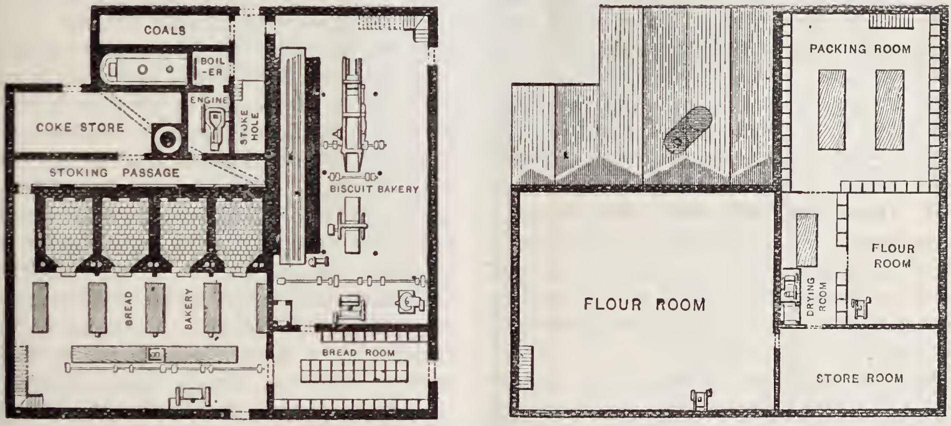
As London examples of modern bakehouses, I will first refer to that erected for the late Civil Service Bread Company, at Horseferry-road, Westminster. The engineer was Mr. W. F. Mason, of Manchester, by whom the bakery was designed and fitted throughout. There are several novel features in the construction of this bakery. From the road, entrance is effected through a yard, in which the bakery is erected as an independent building. On the ground-floor is first the bread or cooling-room, yeast-room, and men's offices. Above these are two levels of flour store-rooms. From the bread-room one finds one's way direct into the bakery, which in this case consists of a large hall lighted direct with a skylight its whole length. On either side are arrangements for twelve double-decker ovens, making altogether a total of forty-eight ovens. Down the centre of the building is run a gallery leading from the flour store-room at the one end. By means of this the flour is brought over the kneading-machines fixed in the floor below. The total capacity of this bakery is reckoned at 5,000 sacks per week. The company whose property it is has recently been reconstituted under the name of the Golden Grain Bread Company.

Fig. 10.



Bread and Ship Biscuit Factory at Bergen, Norway.

Fig. 11.



Bread and Biscuit Factory at Goulbourn, N.S.W.

As another example of modern London bakeries, I may mention that of Messrs. W. Hill and Son, at James-street, Westminster.

For the general mechanical arrangements of this bakery, Messrs. Werner and Pfleiderer are largely responsible. One important point in the construction is that the ovens and bakehouse are situated over the shop and selling department, rather than under. With sufficient space, I need scarcely say how much more advantageous is such an arrangement.

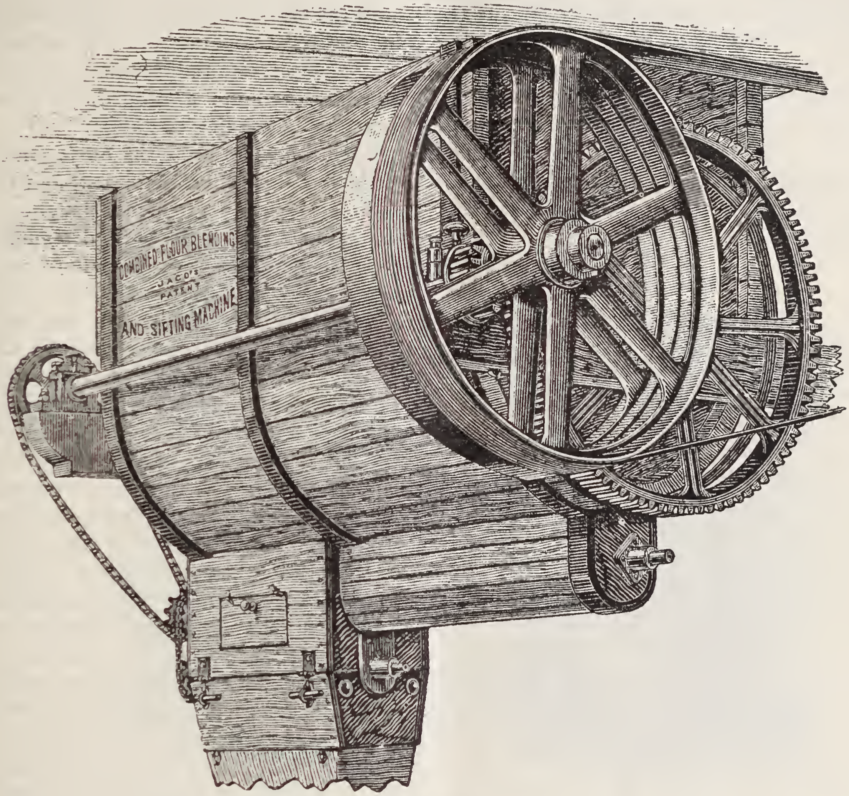
Should any of my audience happen to be visiting Brighton, I am empowered to extend to them an invitation to visit the bread factory recently erected there by Mr. J. J. Clark. It is of considerable dimensions, and is one in which much of the responsibility of construction and design rested with myself. I am, therefore, precluded from saying much regarding it, but may state, as one point of interest, the fact that, in preparing the designs for the whole building, and installation of machinery and ovens, absolute *carte blanche* was given as to expense, and consequently nothing has been spared in providing for the manufacture of bread under the best possible sanitary and hygienic conditions.

I want, in the next place, to refer you to modern bread-making appliances, and give you an outline of them. With regard to these, I purpose taking the question generally of bread-making from the very commencement, and carrying it right through, indicating the types of machinery now being used, and saying something of their general principles. The operations to which I shall refer are not all of them practised by one and the same baker, but I will group together and take in order the various processes to which different bakers subject the materials with which they deal. One of the first operations under these circumstances is that of blending the various flours which are used in making bread, and the great majority of bakers do so blend in some way or other, there being very few who use one variety of flour only.

Blending may be performed by manual labour; in this case the different flours are emptied into either a trough or bin, and turned over by hand, or in the latter case a flour spade, until they are deemed to be thoroughly mixed. Such a method is crude and inefficient, except when only very small quantities are being subjected to the operation. For effectual blending some form of mechanical appliance is necessary; the type varies according to the conditions under which the act is performed. Thus the miller blends flours to a greater or less extent; with him the whole or part of his flour is in bulk, and a very convenient mode of blending is to permit the various kinds of flour to pour into a mixing worm through apertures, the size of which can be controlled at will. The proportioning the different kinds of flour in this type of apparatus depends on the rate of flow through these apertures. By a mixing worm, I mean here the ordinary millers' worm, which consists of a long screw, from about four to eight inches diameter, working in a containing trough. The flour is conveyed along by the screw, at the same time being turned over and over, and thus mixed. The principle is better adapted to the use of the miller than the baker, because the latter has the advantage of already having his flour weighed off in definite quantities, usually of either the sack, 280 lbs., or half sack, 140 lbs. In consequence, the baker takes the sack as his unit, and generally arranges to mix, say, three sacks of one variety, two of another, and one of a third, or any other proportion that may be desired. Various mechanical appliances have been devised for the purpose of effectively blending flours in this manner. A machine of this kind should be able to blend flours in any proportion, and of any variety, so as to quickly produce a perfectly uniform mixture as the result. The most successful of these machines have been those in which the whole of the flour to be mixed is discharged into one receptacle, and there the whole mixed thoroughly together.

The machine here placed before you is one arranged so that it may be fixed underneath the floor of the flour room. The main portion of the machine is a rectangular trough with semi-cylindrical bottom, containing within a large mixing blade, actuated by the belting and gearing you see on the right hand of the diagram. On the floor above the machine is fixed a hopper, through which the flour is discharged into this trough. The baker having decided as to what the proportions of his mixture shall be, simply gives directions accordingly; no valves or similar gear have to be adjusted; simply the required number of sacks or half sacks of flour are brought up, the machine is set working, and the flour is shot in. The mixing blade is so designed that in the course of its revolutions it not only turns the flour over and over, but also gives it an alternating movement from end to end of the trough. The result is that, in about two minutes after the flour has all been discharged into the machine, it is thoroughly mixed. Below this mixing trough a worm conveyer is fixed, and between the two a gridiron slide valve is placed. The gridiron valve is a contrivance in which there is arranged a series of openings alternating with blank spaces. On drawing the slide valve an inch or two in one direction, these openings permit the flour to flow into the worm from every part of the length of the mixing trough ; on moving the valve in the opposite direction, they are again closed. This conveying worm, into which the flour is thus discharged, gives it a second thorough mixing, and at the same time conveys to wherever it is desired. In the machine shown in Fig. 12, the flour is conveyed to a sifting apparatus, by which such accidental impurities as pieces of twine, sack needles, and other incongruous bodies are separated and removed. The blended and sifted flour emerges from the linen or canvas shoot, shown at the left-hand bottom extremity of the machine, at about the rate of a sack per minute. The sifting portion of the machine consists of a semi-cylindrical sieve, over which a series of brushes rapidly revolves, the whole being capable of adjustment by means of various screws and bolts. The form of machine here figured is particularly applicable in bakeries where the kneading is done by hand ; being fixed up under the floor of the flour-room, the flour is readily shot into the machine, and the sifted flour is then drawn off direct by means of the sleeve into the kneading troughs underneath. But, where desired, the flour may be conveyed by the worm to any required point, and if wished may be elevated once more to the flour-room above, and there drawn off once more into sacks. The machine may be modified so as to suit the particular requirements of each individual user.

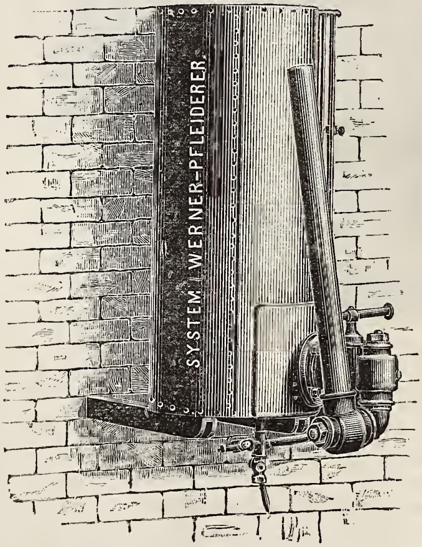
FIG. 12.



JAGO'S COMBINED FLOUR BLENDING AND SIFTING MACHINE.

We must now leave the flour and pass to the preparation of the yeast. A large number of bakers make ferments, or have other special fermentation processes. So far as yeast manufacture is concerned, one of the most interesting machinery plants I have seen is that which was in the first place arranged by and erected for Mr. Feaist, of Hastings. He aggregated together a number of machines for the effective treatment of potatoes for ferment-making purposes. In the first place his potatoes were thoroughly washed by a machine devised for the purpose, and then cooked by steam in a special steaming apparatus. The cooked potatoes were next placed, together with water, in a sifting and crushing machine, and thus reduced to one uniform pulpy liquid, which by means of a small pump is conveyed to a refrigerator, and thus rapidly cooled to the desired fermenting temperature. The same refrigerator serves also the purpose of cooling the wort used for the brewing of yeast. Time forbids a more extended reference to yeast and ferment-making appliances; but before coming to the question of of kneading, there is still another matter to consider. The kneading consists in the thorough mixing together of the flour, yeast, and water required in order to make bread. I have already spoken of the preliminary treatment of both the flour and the yeast, there now remains the preliminary treatment of the water.

Fig. 13.


SYSTEM WERNER-PFLEIDERER.

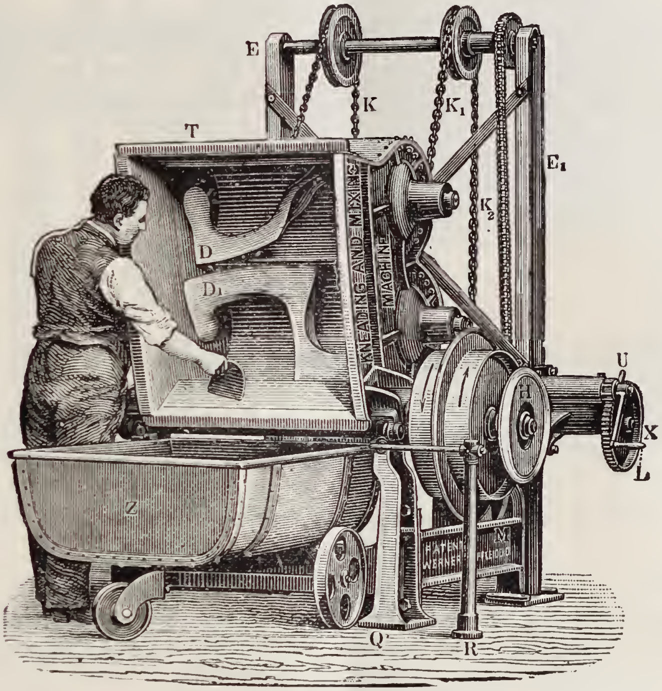
Water-attemperating Cistern.

In a machine bakery particularly, it is essential that the rule of exactly measuring both flour and water is strictly adhered to. Flour is best measured by weight, and water by volume; the latter is also required to be adjusted to temperature for bread-making purposes. Our illustration shows one kind of tank used for this purpose. This tank is affixed in some convenient position, from which the water may be conveniently run into the trough of the dough-kneading machine. This tank is provided with a glass gauge and scale, marked off either into quarts or gallons, by which the exact quantity of water run out is measured. Through the side of the tank a thermometer is fixed, and at the top is an overflow pipe, which corresponds exactly with the zero of the scale behind the gauge. A cold water supply-pipe enters this cistern at the top, and a hot water supply at the bottom. When about to be used, cold and hot water are run simultaneously into the tank until nearly full. The temperature is then observed, and a little more either of hot or cold water is run in until the tank is full to the overflow of water at the desired temperature. The outlet pipe is then directed into the trough of the kneading-machine, and the desired quantity of water drawn off according to gauge.

From this point we pass on to the question of mixing the water, the yeast, and the flour together, so as to produce a dough. A number of machines have been designed for the purpose of doing away with hand work, and in speaking of these machines I should like for a moment to indicate, in the first place, the difference in character between hand and machine made doughs. A good doughing machine will produce a homogeneous dough, that is one which shall be free from dry flour and all unevenness, equally tight or equally slack all over; but at the same time, practically, the mixing action of a machine, however perfect, produces what I call a textureless dough. On the other hand, hand-made doughs, though not so homogeneous, have more texture, and this, to a certain extent, is the actual necessary consequence of the method by which hand-made doughs are worked. Pieces of dough are cut off in the trough, and in the act of kneading are more or less folded over, beaten out, and re-beaten out, in a series of operations that remind one somewhat of the passing of a "bloom" of iron from the puddling furnace through a pair of rollers by means of which a fibre and texture are given to it in the act of being converted into bar iron. In handling doughs the workman may modify his treatment somewhat, according to the character of the dough, because he is, or should be, an intelligent agent, bringing judgment to bear. On the other hand, there is not the same opportunity for such modification of treatment with a doughing machine. Still, after all, my own opinion is very strongly in favour of the use of machinery for the purpose of preparing dough. Some time ago, in a work from which I will now quote, I wrote as follows:—"The operations of kneading and working dough involve severe manual labour in a heated atmosphere. It is impossible to conduct these processes without more or less contamination of the bread with emanations from the skin of the workers. In the best conducted bakeries this evil is reduced to a minimum by insisting on scrupulous cleanliness on the part of the workmen; still even the utmost care cannot entirely abolish the evil. For the strongest of sanitary reasons, both on the part of the public and of the workman, the operations of doughing demand mechanical appliances rather than manual labour." I must say with regard to this, that I see at present no reason for modifying the opinion which is there expressed.

I will now rapidly point out to you one or two machines devised for this purpose of mixing dough. I have the opportunity here of actually showing you a model of such a machine devised by Mr. Pfleiderer, with which I dare say many of you are fairly familiar. There are a pair of blades in the machine which revolve by the action of the handle, and in the act of revolving produces a most thorough and efficient mixing.

FIG. 14.



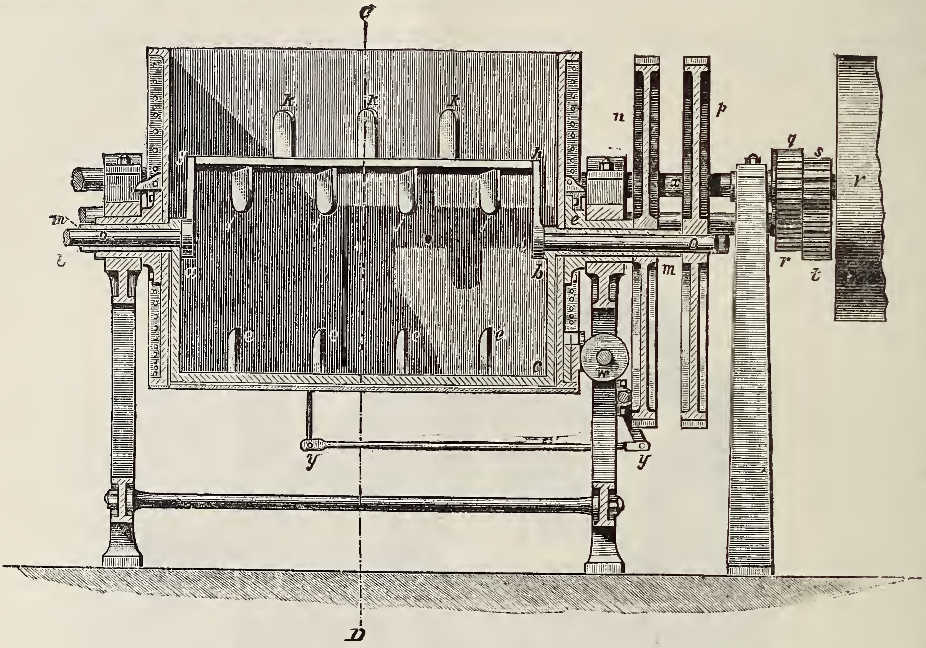
PFLEIDERER'S DOUGHING MACHINE TILTED FOR DISCHARGE.

I now show you an illustration (Fig. 14) of a Pfleiderer's doughing machine, of sufficiently large dimensions for bakehouse use. On the right-hand side of the machine are two pulleys, which are caused to revolve in opposite directions by the use of open and crossed belts respectively. Between these pulleys is a friction clutch, which is operated by a hand-wheel, marked H. The machine being at rest, the hand-wheel can be turned in either direction, and the motion of the blades follows suit; when the machine is in action, stopping the hand-wheel also stops the machine. At the back of the machine are two counterpoise weights, which permit its being easily tilted for purposes of discharge.

On the extreme right hand of the machine there is the handle and gearing, X, by which the tilting operation is effected. The inside of the machine is well shown, and a good idea is gained of the shape of the blades. Let us, for a moment or two, examine the action of these on the flour and water introduced into the machine. The blades bring the flour and water from the circumference to the centre, and then mix them together. As they pass downwards, the dough divides into two pieces, one being carried round by each of the two blades. The gearing is so arranged that these revolve at unequal speeds, and, consequently, the dough carried round by each comes in contact, and mixes with another portion of the mass at each revolution. In this way a perfectly even dough is attained with great rapidity. Without stopping or interfering with the work of the machine, the trough may be uptilted, when the moving blades discharge the dough with the greatest readiness.

I have now to show you a figure of a kneading machine on a different principle, by another maker. This first figure is a longitudinal section through the Thomson machine. There are, it will be noticed, two blades working on the same axle.

FIG. 15.



LONGITUDINAL SECTION THROUGH THOMSON KNEADING MACHINE.

Let me endeavour to explain the principle. The outer kneader, marked *a*, *b*, *c*, is so shaped as to adapt itself to the contour of the interior of the trough. From the inner surface of *c* projects, at right angles to it, a series of blades, *e*, *e*. The second kneader, *g*, *h*, *i*, revolves within *a*, *b*, *c*, on the same centre, and has projecting inwards from it a series of blades, *j*, *j*, and outwards another series *k*, *k*. The outer blades, *k*, *k*, interlace in working with the blades, *e*, *e*, of the outer kneader. All the blades are set obliquely to the direction in which they meet the dough. These blades are capable of the following different motions:—(1st.) Either may be set at work, the other remaining at rest. (2nd.) They may be caused to revolve in opposite directions, when by differential gearing the one revolves more rapidly than the other, and so the two meet at different points at each successive revolution. (3rd.) The two may be locked together at any angle, and caused to revolve as though they were one. A fast and slow speed is provided, so that as the dough becomes stiffer, and offers more resistance, greater force can be exerted by reducing the speed of revolution. The gearing by which these changes are effected is shown at the right-hand side of the machine.

I said just now, with regard to machine-made dough, that it somewhat lacked texture, but this defect may be remedied by use of the dough brake, which is a very simple contrivance, utilising the principle to which I have incidentally referred as being employed for giving fibre to iron, namely, passing it rapidly through a series of rolls. By means of gearing, the rolls can be caused to approach one another or held apart. The dough is passed through, and then re-folded and passed back again. This can be performed as often as required. One result of "braking" dough in this way is to give a very decided texture to it, and consequently pile or texture to the bread. I do not think they are used much in this part of the country, but in Edinburgh and Glasgow, and other parts of Scotland, where they attach considerable importance to the texture and appearance of a loaf, the dough is passed through brakes of this kind after it leaves the kneading-machine; so that, practically, even if the kneader may not be capable of giving the texture to the dough which skilful hand-made dough possesses, yet by the use of another machine such as this, the lack of the former is supplied.

Obituary.

REV. STEPHEN JOSEPH PERRY, D.SC., F.R.S.—The Rev. Dr. Perry, the eminent astronomer of Stonyhurst College, died of dysentery while engaged on the expedition off the coast of French Guiana, to observe the total eclipse of Dec. 22nd. Father Perry was born in London, in 1833, and entered the Society of Jesus in 1856. He was elected a Fellow of the Royal Society in 1874, and enriched the Philosophical Transactions of that body with papers containing the results of work at the Stonyhurst Observatory, as well as of some of the many expeditions he was connected with, such as the magnetic survey of France, in 1868-9. He was engaged in the observation of the transit of Venus in 1874 and 1882, and of the eclipses of the sun of 1886, 1887, and 1889. He was elected a member of the Society of Arts in 1888.

General Notes.

FRANKFORT ELECTRO-TECHNICAL EXHIBITION.—It is proposed to hold at Frankfort-on-the-Main an International Electro-Technical Exhibition from 1st June to 31st October of the present year. The exhibition will include all branches of the electrical science and industry, but as a rule only those exhibits will be admitted which show a decided improvement on those of the last special exhibitions at Munich in 1882 and Vienna in 1883. The exhibits will be divided into twelve great groups, commencing with motors for electro-technical purposes, and ending with electrical literature. Applications should be made before the 15th inst., and addressed to Mr. Leopold Sonnemann, editor of the *Frankfurter Zeitung*, Frankfort-on-the-Main.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

JANUARY 15.—Adjourned discussion on SIR ROBERT RAWLINSON'S paper on "London Sewage." SIR HENRY ROSCOE, F.R.S., M.P., will preside.

JANUARY 22.—R. BRUDENELL CARTER, F.R.C.S. Vice-President of the Society, "Vision-testing for Practical Purposes."

JANUARY 29.—GILBERT REDGRAVE, "The Utilisation of Blast-furnace Slag."

FEBRUARY 5.—ARTHUR PAGET, "High-speed Knitting and Weaving without Weft." W. ANDERSON, Vice-President of the Society, will preside.

FEBRUARY 12.—GEORGE FINDLAY, General Manager London and North-Western Railway, "Modern Improvements in Facilities for Railway Travelling."

FEBRUARY 19.—Prof. SILVANUS P. THOMPSON, "The Organisation of Secondary and Technical Education in London."

SIR DOUGLAS GALTON, K.C.B., D.C.L., F.R.S., Vice-President of the Society, "The Chemin de Fer Glissant, or Sliding Railway."

G. N. HOOPER, "Carriage Building and Street Traffic in England and France."

J. S. KELTIE, "Commercial Geography."

J. TRIPPLIN, "Recent Progress in British Watch and Clock Making."

ARTHUR MONTEFIORE, "The English in Florida."

FOREIGN AND COLONIAL SECTION.

Tuesday afternoons, at Five o'clock:—

JANUARY 21.—JOHN LOUDOUN SHAND, "The Tea, Coffee, and Cocoa Industries of Ceylon."

FEBRUARY 18.—J. HENNIKER HEATON, M.P., "Ocean Penny Postage and Cheap Telegraph Communication between England and all Parts of the Empire and America."

MARCH 18.—A. LASENBY LIBERTY, "The Industrial Arts of Japan."

C. G. WARNFORD LOCK, "Gold Mining in Hungary."

INDIAN SECTION.

Friday afternoons, at Five o'clock:—

JANUARY 17.—F. C. DANVERS, Registrar and Superintendent of Records, "The India-office Records."

A brief account of the results of an examination, during the last six years, of the records relating to India and the East India Company now in the possession of the Secretary of State for India. LORD HARRIS will preside.

SIR J. THEODORE HOPE, K.C.S.I., "The Rationale of Indian Railways."

T. TALBOYS WHEELER, "Old Madras."

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock:—

JANUARY 28.—EDWARD C. ROBINS, F.S.A., "The Relation of the Fine Arts to the Applied Arts."

FEBRUARY 11.—W. R. LETHABY, "Cast Iron and its Treatment for Artistic Purposes."

MARCH 4.—JAMES ORROCK, R.I., "The Claims of the British School of Painting to a thorough representation in the National Gallery."

[Pictures by illustrious English masters whose works are not included in the National Gallery will be exhibited by Mr. Orrock.]

MARCH 25.—H. ARTHUR KENNEDY, "Glass Painting."

APRIL 15.—C. PURDON CLARKE, C.I.E., "Modern Indian Art."

MAY 13.—Prof. W. C. ROBERTS-AUSTEN, F.R.S., "The Use of Alloys in Art Metal-work."

CANTOR LECTURES.

Monday evenings, at Eight o'clock:—

Prof. SILVANUS P. THOMPSON, "The Electromagnet." Four Lectures.

LECTURE I.—JANUARY 20.—*Introductory.*—Historical. Generalities about uses and forms of electro-magnets. The magnetic properties of iron: induction; permeability; hysteresis.

LECTURE II.—JANUARY 27.—*Principle of the Magnetic Circuit.*—Experimental data. Predetermination of iron and copper for given traction. Heating of coils.

LECTURE III.—FEBRUARY 3.—*Special Designs.*—Various forms and their uses. Electromagnets for quickest action; for longest range; for maximum traction; for minimum weight; for alternate currents; for series work; for parallel work.

LECTURE IV.—FEBRUARY 10.—*Electromagnetic Mechanism.*—Range of action of various forms of electromagnets. Plunger and coil. Equalizers. Modes of preventing sparks.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JAN. 13...East Coast Institution of Engineers and Shipbuilders, Newcastle-on-Tyne, 7¾ p.m. 1. Discussion on Mr. Charles B. Casebourne's paper, "The Construction of Marine Boilers with a view to the Use of Higher Pressures." 2. Mr. E. Hall-Brown, "High-speed Engines for Cargo Boats."

British Architects, 9, Conduit-street, W., 8 p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Sir Philip Magnus, "University Education in London."

TUESDAY, JAN. 14...Medical and Chirurgical, 20, Hanover-square W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. George Fosbery Lyster, "Recent Dock Extensions at Liverpool."

Photographic, 5a, Pall-mall East, S.W., 8 p m.

Anthropological, 3, Hanover-square, W., 8½ p.m.

Biblical Archæology, 9, Conduit-street, W., 8 p.m. Annual Meeting.

Zoological, 3, Hanover-square, W., 8½ p.m. 1. Mr. R. Lydekker, "A new Species of Otter from the Lower Pliocene of Eppelsheim." 2. Mr. G. F. Hampson, "A Complete List of the Sphinges and Bombyces known to occur on the Nilgiri Hills of Southern India, with Descriptions of new Species." 3. Prof. Bertram C. A. Windle and Mr. John Humphreys, "Some Cranial and Dental Character of the Domestic Dog." 4. Mr. G. A. Boulenger, "Fourth Contribution to the Herpetology of the Solomon Islands."

Colonial Inst., Whitehall-rooms, Hotel Métropole, Whitehall-place, S.W., 8 p.m. Mr. William Keswick, "Hong Kong and its Trade Connections."

WEDNESDAY, JAN. 15...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Adjourned discussion on Sir Robert Rawlinson's paper, "London Sewerage and Sewage."

Meteorological, 25, Great George-street, S.W., 7¼ p.m. 1. Annual General Meeting. 2. Dr. Marcet (President), "Atmospheric Dust."

Entomological, 11, Chandos-street, W., 7 p.m. Annual Meeting. Address by the President, the Right Hon. Lord Walsingham.

Archæological Association, 32, Sackville-street, W., 8 p.m.

Inventors' Institute, 27, Chancery-lane, W.C., 8 p.m. 1. Mr. S. J. Mackie, "Lessons Deducible from Recent Fires." 2. Papers on inventions for minimising the dangers of fires and saving human life, by Capt. Fairholme, R.N., Mr. Vinning, Mr. F. Jones, Mr. Hoblyn, Colonel Wethered, and other members of the Institute.

THURSDAY, JAN. 16...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Mr. A. Barclay, "Life History of a remarkable Uredine on *Jasminum grandiflora.*" 2. Mr. E. Prince, "Certain Protective Provisions in some Larva, British Teleosteans."

Chemical, Burlington-house, W., 8 p.m.

London Institution, Finsbury-circus, E.C., 6 p.m. Mr. D. Morris, "The Sugar Islands of the West."

Camera Club, Bedford-street, Strand, W.C., 8 p.m. Mr. R. Tindall, "Plane Polarisation of Light." (With Illustrations.)

Numismatic, 4, St. Martin's-place, W.C., 7 p.m.

Historical, 11, Chandos-street, W., 8½ p.m.

FRIDAY, JAN. 17...SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m. (Indian Section.) Mr. F. C. Danvers, "The India-office Records."

Physical, Science Schools, South Kensington, S.W., 5 p.m. 1. Mr. F. B. Hawes, "A Carbon Deposit in a Blake Telephone Transmitter." 2. Prof. S. P. Thompson, "Electric Splashes." 3. Prof. W. E. Ayrton and Messrs. T. Mather and W. E. Sumpner, "Galvanometers."

Journal of the Society of Arts.

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FRIDAY, JANUARY 17, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Proceedings of the Society.

CANTOR LECTURES.

MODERN DEVELOPMENTS OF BREAD-MAKING.

By William Jago, F.C.S., F.I.C.

Lecture IV.—Delivered December 16, 1889.

It is my intention to devote the earlier part of this fourth lecture to the completion of our study of the mechanical appliances in use by bakers. Following that, I purpose touching on one or two other matters which are, I think, of considerable public interest.

In our treatment of the various utensils employed by the baker, we have practically brought the bread to the state of being finished, so far as the preparation of dough is concerned. There remains before us the question of baking, and with this I wish to deal to-night, as extensively as time will permit.

The baker's oven consists essentially of a heated chamber, in which the bread to be baked is placed. The older types of ovens vary somewhat in pattern, according to the part of the country in which one sees them. A very common type in the south of England is that known as the "side flue" oven. This oven is a brick structure with either a tiled or stone sole. The "sole" of the oven, it should be explained, is the floor, while the "crown" is the roof. In the side-flue, and most ovens of that type, the crown consists of a brick arch. In the front of the oven, opening into the bakehouse, is the oven door or "stock," while on the one side of the door is the furnace. This is a fireplace, the flue from which leads direct into the oven. This furnace is fired, of course, from the bakehouse. On the other side of the oven door is an exit flue, by which the products of combustion escape to the chimney. Another and probably earlier type of oven is that in which the fire is placed within the oven itself; ovens of this kind are still extant, particularly in districts where wood is used as fuel. Within the last few years, ovens of this kind have been built and used in London. A development of this particular oven, where the fire is made on the sole itself, is the waggon or chaffer oven. These are still largely used in Manchester and neighbourhood. The chaffer consists of a moveable iron furnace, placed within the oven, and moved about from part to part, so as to evenly heat the whole of the interior. All these forms of ovens, be it noted, are internally heated, that is to say, either the fire or the products of combustion direct from the fire, find their way inside the oven and heat it from the inside. Let us see how these ovens are used. Some time before the oven is required for baking purposes, the fire is made up and allowed to burn for such a time as experience suggests is necessary, in order to obtain an adequate heat. At this stage, the door of the oven and all flues and passages are closed, and the oven allowed to settle down; gradually the whole of the interior acquires a more or less equable temperature. The longer the period which elapses between the firing and the baking, other things being equal, the more even does the temperature become. Previous to use, the oven is washed and wiped out by what is technically known as a "scuffle." This consists of a large piece of suitable washing material, securely fastened to the end of a long pole. The scuffle is dipped into a bucket of water, and then scrubbed around vigorously inside the oven. In this manner any ashes or remains of the fire are removed, and the immediate surface of the oven sole is slightly cooled. A natural consequence of the construction and mode of using a side-flue oven is that the front or mouth of the oven is the hottest part. This is in great part compensated for by the fact that the bread is first put into the back or head of the oven. What occurs, therefore, is that the cooler part of the oven holds its bread longer, and, consequently, the bread is baked more evenly than at first thought one would suppose. All such ovens are loaded by what bakers call a "peel," this implement being a species of flat wooden spade, with a handle some ten or twelve feet long. In speaking of ovens, I wish to-night to take a sack oven as the basis of comparison, by which I mean one that holds the bread from one sack of flour. This will have about 66 square feet of baking surface. To fill the sack oven with a peel occupies about 15 minutes. With halfquartern (2 lb.) loaves, the length of time for baking varies from 45 to 60 minutes. This will be the average period where bread such as we have here is baked; that is to say, with loaves which are crusty all round, and have the advantage of the heat playing all over the loaf. When the bread is "close-packed," or crumby, that is to say, when the loaves are placed side by side, and touching each other, so that they have only a top and bottom crust, and the heat can only approach them from the top and bottom, the time taken for baking is considerably longer. The bread being baked, the unloading of the oven occupies generally about ten minutes, so that the first loaf is in the oven from twenty to twenty-five minutes longer than the last. This, as I say, is more or less compensated by the lesser heat of the oven at the head. On the withdrawal of one batch, the oven requires to be again fired previous to the admission of the next. The minimum amount of time required for the operations of firing, scuffling, and preparing the oven for the next batch is about thirty minutes. Probably forty-five minutes would be still better, because with too rapid heating the inequalities of temperature are far more marked; the oven is "rash," and more likely to burn the bread than if allowed to settle down for some little time before being again used. From the admission of one batch of bread to the admission of another in an oven of this type, baking half-quartern crusty loaves, the minimum time averages about an hour and fifty minutes, of which some forty-five or fifty minutes are taken up in baking, and the remainder in filling, emptying, and firing the oven.

In the side-flue, in common with other varieties of ovens, the bread is heated at the bottom by conduction of heat direct from the sole, the two being in contact. The top of the bread is heated by direct radiation from the crown of the oven.

These side-flue ovens and their congeners have done us good service; nevertheless new forms of oven have been, and are being, invented in great numbers. As a preliminary to their consideration, it will be well, I think, for us to glance at what are the actual requirements in an oven. These, in the first place, somewhat depend on the nature of the trade being done. In the case of large factories, baking bread only—and of that perhaps only one or two kinds—you simply require ovens specially suited to that particular purpose. Provided they bake this one type of bread well, it is no detriment that they may be unsuited for other purposes. Further, where a large trade is being done, even of a varied description, the organisation and arrangement of the work will be such that different ovens, each specially adapted to the particular purpose, will be employed in each department. The ovens for large factories then should be specialised, each being carefully adapted to the kind of work which it has to do.

Then, on the other hand, you have the smaller bakeries, in which perhaps one and the same oven, or at most a pair of ovens, must be adapted for baking not only bread but cakes, pastry, and the many descriptions of goods turned out by the confectioner, and known by him under the name of smalls. Let us remember first of all, however, what we require with regard to bread. We have two or three things to consider. We have to provide for what may be called the hygienic conditions necessary, and we have to consult the actual requirements of the baker himself, so far as the conveniences of his trade are concerned. First of all, one matter of great desirability with ordinary side-flue ovens is that the firing, if possible, should be done outside the bakehouse rather than from within. The reasons for this change are, I think, self-evident. It is far better, where possible, that coal, coke, and fuel generally should not be brought into the bakehouse, and, further, that the ashes and necessary dust of the fires should not find their way in and out through the same part of the building as that in which flour is actually being converted into bread. Therefore I say, if possible, ovens should be fired outside the bakehouse.

The next point on which I will insist is that the bread must not be injured by the products of combustion. A great deal of debate might very well arise around this point, and I think we should find one school of oven builders, and one class of bakers, arguing exclusively in favour of externally-heated ovens—that is to say, ovens in which no part whatever of the products of combustion find their way into the interior of the oven. On the other hand, we should find that a number of bakers pin their faith to an oven which is internally heated, and are very firm in their convictions that an oven in which the heated gases from the fire find their way inside the baking chamber turns out bread which, in appearance and general character, is superior, because of its internal heating. Therefore, here we are on somewhat debatable ground. Everyone, however, will unite in opinion on this point to which I have just referred—that whether the products of combustion find their way into the oven or not, they certainly must not do so so as to cause any injury to the bread itself.

Another great advantage would be that the oven shall be smokeless, and this advantage is a much greater one the larger the town in which the oven is situated. The advantage probably will be greatest of all—I do not say so much to the baker, but to his fellow-citizens—in London itself. Bakers themselves talk and write on agitating for a repeal of the Smoke Nuisance Acts, but I must say plainly my own opinion is that if ever those Acts are again considered by Parliament, it will be with a view not to repealing any of those Acts but to making the conditions more stringent. It would be all very well, of course, if we had nothing to do but to make bread, but, as a matter of fact, the general public think very much more of the nuisance which smoke is, than of the convenience it might be to the baker to be permitted to produce more smoke than he is now allowed to do. I am of opinion, therefore, that as even at present a good many bakers find themselves contravening the conditions of this Act, and in view of the fact that in future these conditions may be more stringent, there are very cogent reasons for the adoption of smokeless ovens.

In the next place, the oven itself should be economical of fuel. Economy of fuel, however, requires to be considered in connection with one or two other points to which reference must subsequently be made. In judging of the economy of the oven in fuel, several conditions must be remembered. First of all, there is the question of its variation in actual cost or price according to the locality, and notwithstanding the great differences which exist, one finds all sorts of fallacious comparisons made between the cost of fuel per sack of flour which is baked in ovens erected in different places. Another point is that the economy in the matter of fuel of the oven is governed by the number of batches of bread which are baked in that particular oven per day. If you take as one example a baker's trade in which bread is perhaps being baked from the first thing in the morning, say 4 o'clock, until late at night, where bread is being baked, in fact, all day long, you have conditions which will cause that oven to be more economical, so far as fuel is concerned, than the oven of another baker who has of necessity to get the whole of his bread baked, and the delivery to his customers started, perhaps, by 7 o'clock in the morning. The one man may be able to bake seven or eight batches of bread during the day in his oven, or even more than that if his oven is a continuous one. The other cannot possibly bake more than four or five, and the result is that the one who bakes the greater number will bake his bread with greater relative economy of fuel.

This leads me to the next point, which is that of the continuous baking of bread. This means of course greater speed of oven and greater speed of baking, and that means a saving of space, because a smaller number of ovens would be capable of doing the same work, and also a saving of men's time, both of which are of immense importance, and the former particularly in towns where space is valuable. Practically, continuous baking is absolutely necessary where bread has to be turned out with great speed.

In the next place, an oven should bake bread evenly. I do not say here, you will notice, that the oven should bake at exactly the same rate over its whole surface—that will depend on circumstances—but the oven should be so arranged, especially if it be used for bread entirely, that the bread drawn from any and every part of the oven should receive practically the same amount of baking. Then the oven should be such that the bread in appearance and bloom should be satisfactory. The word "bloom" is almost self-explanatory, but to those who are not acquainted with the technicalities of baking, I may mention that the bloom of bread refers to the colour of the crust. A crust would be said to be a bloomy crust which was of a delicate yellow tint, a yellow shading off into brown; and other bread which was of a sickly pale tint, greyish rather than yellow, would be said to be devoid of bloom. An oven should be simply and easily worked, and every oven should permit of ready control by the user. The work done by the oven should be steady and constant in character, and, as a necessary corollary of this, the heat of the oven should be solid, that is to say, instead of the temperature rushing up and down very quickly, the oven itself should be maintained at a constant temperature over a considerable length of time. It is further important—and this is a structural point—that the oven and oven-door should be steam-tight, in order that no steam, or very little, should escape from the oven during the act of baking, as loss of steam in this way means very considerable loss of heat.

Now, to their maximum extent the whole of these advantages cannot be obtained simultaneously. Firing outside the bakehouse takes more time in the sense that the man who is firing has to leave the bakehouse and get round to the back or sides of his oven. If the products of combustion are kept entirely out of the oven, the advantages to which I have incidentally alluded attending what bakers call a flashing heat are in part lost. Then greater economy of fuel is obtained by means which militate against steadiness and solidity of heat. Let me explain myself here a moment by an illustration of an oven which is heated by external flues surrounding the baking chamber. The thinner the partition between the flues and the oven itself, the more rapidly does the oven become hot, and with the less expenditure of fuel. On the other hand, an oven such as this would be the reverse of steady in heat. It would answer with very great quickness to every rise and fall in the temperature of the fire itself, and so the greater economy of fuel would be obtained, if you pushed economy to its extreme, by a loss in the steadiness and solidity of the temperature. On the other hand, suppose that these partitions between the oven and flues are very much thickened; the result is that great steadiness of temperature within the oven is attained, but large quantities of fuel have to be burned, because, through the slow conducting power of these partitions, much of the heat escapes up the chimney. The aim, therefore, of the oven builder must be to so proportion the different dimensions of his oven as to obtain the best all-round results, neither sacrificing steadiness of heat to extreme economy of fuel, nor sacrificing reasonable economy of fuel to an effort to maintain absolutely without change the solidity of heat of the oven.

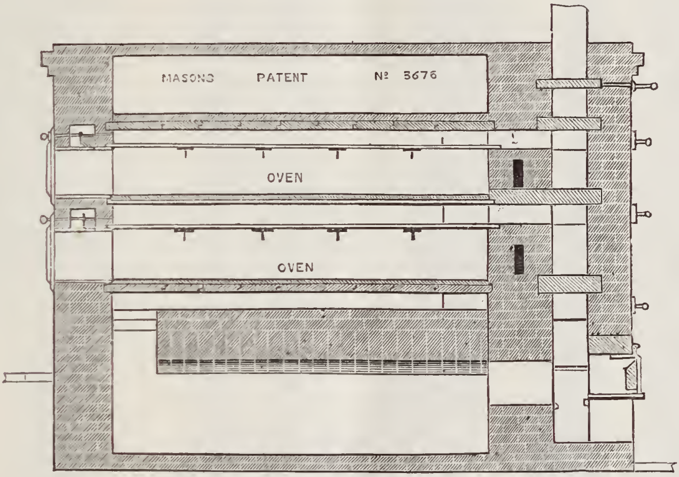
The materials employed in oven building have a very important effect on the character of the oven, and of the bread which is baked in it. These materials belong to two classes, first, those composed of clay, second, those of iron. The whole of the fire clay materials are closely allied to bricks, the only important difference being that they are made thinner and of varying shape to suit the requirements of the oven builder. Some kinds of stone are employed as substitutes for bricks or tiles, particularly for the soles of ovens. The older forms of ovens, as the side-flue and chaffer types, to which I have referred, are built exclusively of materials belonging to this class. Let us consider at this stage those properties of bricks which are likely to affect the baking of bread. First of all, bricks are a material of a porous nature, and, of course, with regard to a loaf which is placed on any surface to bake, the steam must of necessity escape; a loaf of this kind (half-quartern crusty) will be some 2½ oz. less in weight when it leaves the oven than when it entered, and that quantity of water, in the form of steam, must have escaped, and will escape naturally, from every part of the loaf. When you have the bread resting on a porous surface you can easily understand it permits the escape of steam more readily underneath the loaf than where it rests on a surface of non-porous material. In the next place, compared with iron, bricks are distinguished by being bad conductors and good radiators of heat. In consequence of the former of these properties, heat is conducted by them more slowly and evenly, and hence we get some explanation of the thicker bottom crust which is characteristic of the tile-soled oven. The greater radiating power of bricks causes the amount of heat radiated from the crown of the oven to be more in quantity with the same temperature of the material of the crown. Putting it another way, the brick surface itself need not be so hot as an iron surface would have to be in order to radiate heat to the same extent.

Iron is distinguished from brick by being a good conductor and bad radiator of heat; further, it is, of course, non-porous. Bread baked on an iron sole has a thin and somewhat tough crust, the latter property being probably due to the greater retention of steam as a result of the non-porosity of the material. One recently introduced improvement in iron soles is to have them constructed of cast iron, the baking surfaces being left in the rough state in which they come from the sand. These minute irregularities permit much more readily the escape of steam from underneath the loaf during the act of baking. Inferentially, the characteristics of iron have been described during our explanation of those of bricks. To radiate the same amount of heat, the inner surface of the iron (that is, the surface forming the interior of the oven) must be at a higher temperature than in the case of brick. This higher temperature is readily attained because of its greater conductive power. But as a result of the readiness with which heat find its way through iron, there is not the same steadiness and solidity as characterise brick as an oven-building material.

In connection with this, it is interesting to note that the actual nature of the heat radiated from the two surfaces may differ somewhat in character. Of course the lower the temperature at which radiation occurs, the greater is the wave-length of radiated heat. On the other hand, when you come to iron which is radiating heat at a high temperature, the mean wave-length of the radiated heat is less, the waves are quicker and shorter, and that difference in the character of the radiant heat may go some part of the way at least towards explaining why, with regard to ovens in which iron enters largely into their construction, there is somewhat greater difficulty in obtaining adequate soaking or cooking powers through a loaf, and, at the same time time, avoiding the effect of a sharp heat in burning the outside crust.

Having indicated the leading characteristics of brick and iron, we will sum up the general properties of ovens of each type of construction, and will take it for granted that in every case we are dealing with good ovens of their class. Taking a brick and tile constructed oven, we define them as being ovens which are of a solid, mellow, and good soaking heat. Not only in actual temperature but also in quality, the heat may be different, as already explained. In order to first heat a brick and tile oven, a larger proportion of fuel is required, but the heat is retained better by an oven built of these materials. In the next place, with regard to iron constructed ovens they are not so solid as those of brick in heat. (I think that this word "solid" explains itself satisfactorily to the general idea.) They burn the bread more easily without soaking, but are more quickly heated and cooled. In actually describing for you, as I purpose doing, some two or three makes of oven, I will commence with referring to a rather well-known type, which is known as the Mason oven, built by Mr. Mason, of Manchester, of which examples may be found in the Civil Service Bakery at Westminster, the very large bakery to which I have already referred, and which is now occupied by the Golden Grain Company. Those are essentially externally-heated ovens; that is to say, the flues from the fire pass under and over the oven chamber, and so heat it to the desired temperature. These ovens have a crown of iron, and sole of tile.

Fig. 16.

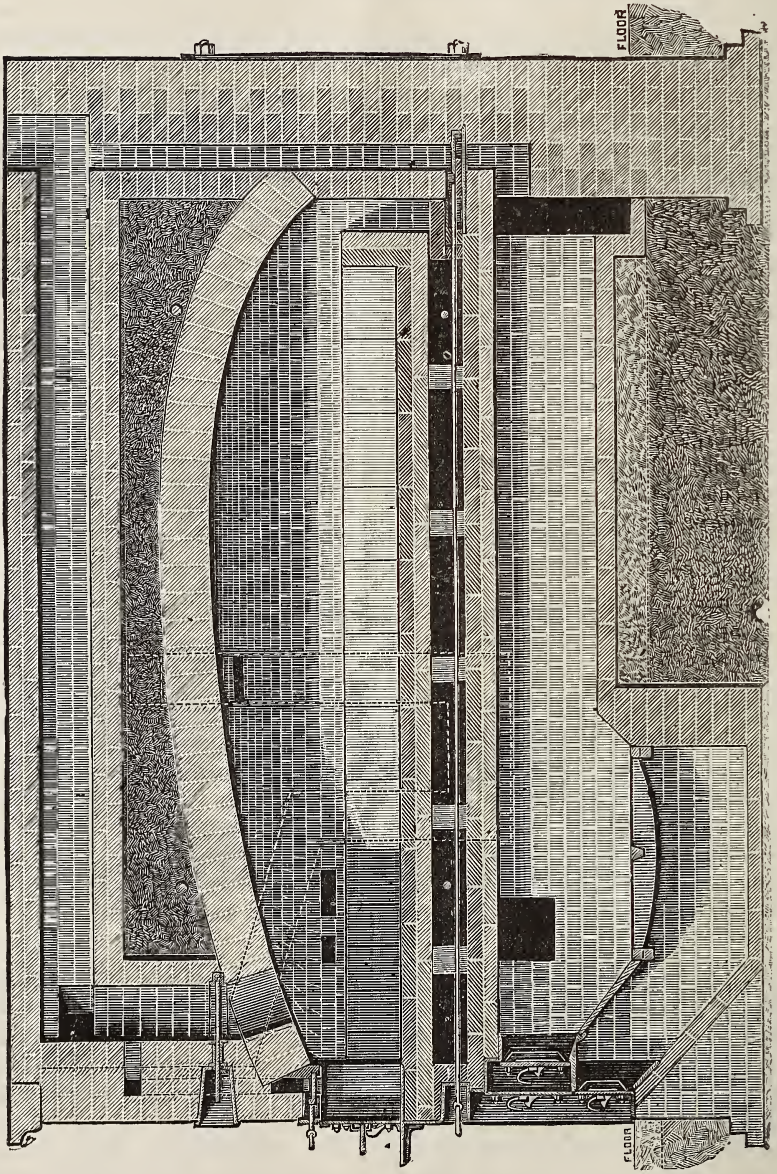


"Mason" Two-decker Oven, Longitudinal Section

The accompanying figure will assist in rendering clear the construction of this oven. The furnace is at the back (right-hand side of figure), and is quite independent of the oven baking chambers. In order to prevent direct conduction of heat from the furnace through the back of the oven, a cold air chamber is placed between; through this a current of air can be permitted to pass at will.

The heated gases from the furnace pass first into a main flue, and come in contact with the oven sole at the front, and from thence pass to the back of the oven. From here they pass between the crown of the lower and the sole of the upper oven; continuing their course, the heated gases next pass over the top of the higher oven, and from thence to the chimney. By means of dampers in the flues, the heat may, when desired, be applied to both top and bottom of each oven, or to either top or bottom only, or may be directed straight up the chimney. In this way the baker secures control over the heat of each oven.

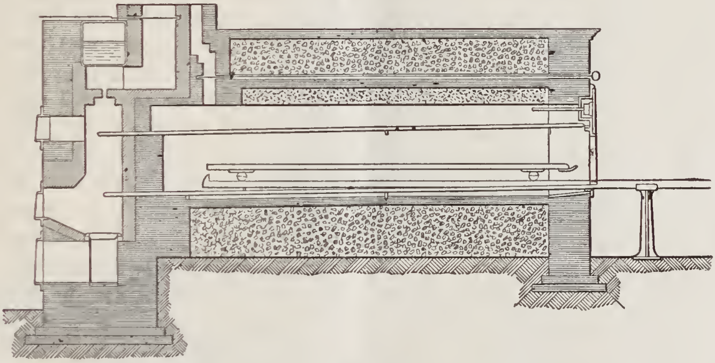
Fig. 17.



Bailey-Baker Oven, Longitudinal Section.

I will, in the next place, direct your attention to a variety of oven known as the Bailey-Baker oven. This has the furnace directly underneath the oven door, and it is consequently fired from within the bakehouse. The main flue extends the whole length of the oven underneath it, but between the flue and oven there is a space which constitutes an air chamber. There are means for taking the products of combustion directly into the oven if desired, and from thence they find their way out of the oven and into the chimney. The merits and advantages claimed by the makers for this particular kind of oven are that it can be used either for an externally or internally heated oven. By carrying the products of combustion entirely round the oven, you get an externally heated one, but by opening a series of valves or dampers, you can allow the products of combustion to find their way into the inside of the oven, and you get the oven heated internally. With regard to an oven of this kind, the necessity for scuffling is reduced to a minimum, there being, of course, no fire within the oven. Possibly, at times, even if fired carefully, fragments of coke may be driven over with the flame into the oven itself, but that only very rarely occurs, and even then does not lead to the same amount of material finding its way into the oven as when the actual fire is burnt, either in the oven or in a closely adjoining furnace, the sole being covered with ashes. An oven of this kind provides means by which a greater speed of baking is obtained. The interval for firing and scuffling, except the very elementary scuffling to which I have referred, is dispensed with, because during the time the bread is being baked a fire is maintained in the furnace, and that fire may be heating the oven externally all the time the baking is going on. In that way you may avoid the necessity of having an actual interval in which the oven is fired between the batches, and during which baking must of necessity be arrested. In the side-flue ovens, to which I have referred before, the interval for heating the oven was put at 25 to 30 minutes. In the case of this oven, the "Bailey-Baker," and also the "Mason" oven, which I have just described, the interval should be reduced where the work is done properly to that necessary for loading and unloading, that is to say, 30 minutes. Certainly, when properly used, there should be little or no time required to heat the oven between the batches, so that we have in ovens of this kind some 20 or 25 minutes only between the two batches of bread, that being the time required in order to fill and discharge the oven.

FIG. 18.



WERNER AND PFLEIDERER'S STEAM OVEN, LONGITUDINAL SECTION.

We will now pass on to an illustration of what is known as a steam oven. With regard to these ovens Perkins's name is one of those associated with the very early type. They are distinctly different in principle to those we have been discussing.

The oven here represented (Fig. 18) is one of Werner and Pfleiderer's, known as the Weighorst, and one of the best at present in the market. I will explain in the first place the method by which these ovens are heated. The oven fires are at the back. We have entering the oven a series of iron tubes or pipes extending the whole length, which slightly incline downwards. Each pipe contains a certain quantity of water, which is hermetically sealed up in the pipe. The influence of the fire is that the water in these pipes is converted into steam; not only steam, but into superheated steam, and superheated steam, as you know, has a temperature corresponding to the pressure which it exerts. If you get a pressure of 50 to 100 atmospheres, you may easily and readily, if necessary, heat the oven up to a temperature far above that at which bread can be baked. These ovens were described by me sometime ago, and I think the description is a fairly happy one, as being ovens that are externally fired but internally heated. The whole firing is done outside, but the heat is conducted into the oven in an exceedingly direct manner through this series of pipes. Above there is a hot water heating arrangement which we have not time to discuss, and there is a damper which controls the whole fire, and so the general heat of the oven.

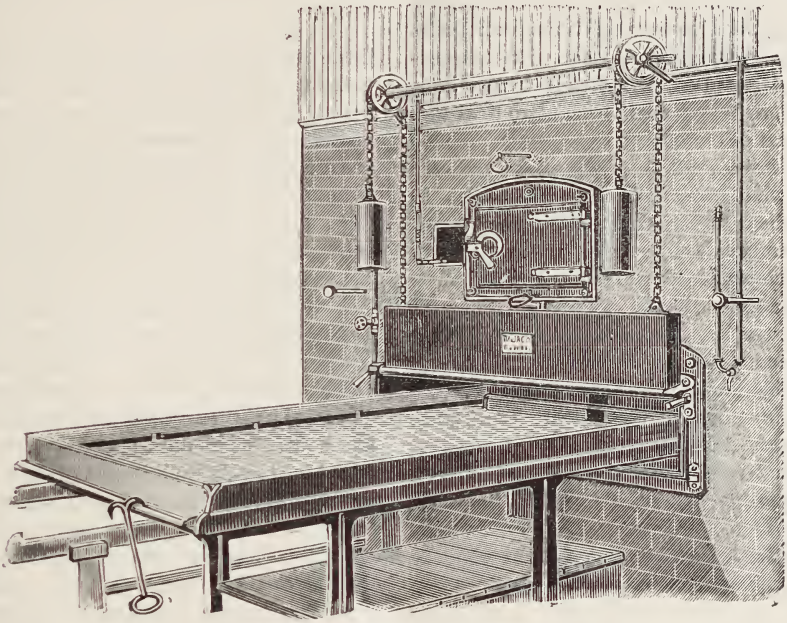
Let me, in the next place, direct your attention to some other points with regard to this oven. The whole of the plate on which the bread is baked is withdrawable, It is fixed on a series of wheels which run on a tramway coming out of the oven into the bakehouse. In using the oven, the plate is withdrawn and loaded with bread, and then pushed back immediately into the oven. When the baking is completed, the plate is withdrawn with the whole of the baked bread upon it. The results from an oven of this kind are very satisfactory. It is well under control, it may be heated quickly, but cools also somewhat rapidly, and has an occasional tendency, unless carefully watched, to overheat the bread. Its characteristics, in fact, must be described, I think fairly, as those of an oven into the construction of which iron enters. The source of heat is at the back, and from the slope of the pipes it naturally ensues that the hottest part of the upper series is nearest the bread. On the other hand, in the lower series of pipes the part which is hottest is further from the bread, and as the whole oven chamber is largely heated by this lower series, that, to a certain extent, compensates for the somewhat greater heat which you have at the head of the oven from the upper series. The back of an oven of this kind is slightly the hotter, and taking this sketch as being illustrative not merely of the draw-plate oven but of the peel oven of this type, the result is that bread baked at the head of a peel steam oven is almost invariably baked more highly than bread at the front. Where the draw-plate modification is used, then the whole of the bread, by entering and leaving the oven simultaneously, obviates the difficulty caused by the length of time necessary to load and unload the oven by means of a peel. A draw-plate holding some 200 loaves can be loaded in about three minutes, and unloaded in the same time; and as all the bread is in the oven the same period, there is consequently great speed in working and equality in baking. In an oven of this type the time necessary between batches is reduced to something like fifteen minutes, that time being required in order to raise the oven to its initial baking temperature between the batches. With sufficient space in front of the oven, it is my opinion that the withdrawable plate oven is the effective bread-baking oven *par excellence*. I have just said with regard to it that a certain amount of time is of necessity required between the batches in order to get the oven heated again for the next batch of the series. That time, I think, may be fairly said to be, certainly when the oven is carefully used, not more than the fifteen minutes estimated; but a certain interval between the batches is necessary if one wishes work of the best class to be done.

The next oven is Jago's. It represents practically an oven built by myself some little time ago, which is at present on show at the Exhibition being held in Brighton. I may state very briefly that this oven is fired at the back, and is an externally-heated flue oven. The flue leads from the fire forward underneath the oven sole, and then certain flues pass along the front, and the heat passes back again between the lower and upper ovens, after which the flue is led over the top oven. The oven is fitted with a door held by balance weights suspended above. It has a draw-plate which, in this case, instead of being of iron, is built up of tiles, so that the bread is baked entirely on a tile surface. The sole of the oven—I mean the under sole, not this travelling sole—is of tiles, and so also is the crown. It is entirely composed of bricks or tiles, heated by means of a series of external flues. The upper oven of the two, which is arranged as a lower temperature oven, is heated by the waste heat from the lower oven, instead of permitting that waste heat to ascend into the chimney direct. The upper oven of the pair may be constructed either as an ordinary peel bread-baking oven or a cake oven (that is an oven at a lower temperature for baking cakes, and so on), or it may be specially fitted for use as what is called a Vienna oven. These ovens are built with the sole and crown sloping upwards from the oven door, and are employed for baking what is termed Vienna or glazed bread. The glazing is effected by keeping the oven full of steam, and as steam is much lighter than air, the slope is given in order to prevent it—the steam—falling out on the door being opened.

The details of construction of this oven may be considerably varied; thus the withdrawable plate may be dispensed with, and the oven used either as a single or double peel oven. Further, the firing may be done at either the back, front, or side, although, when possible, it is far preferable to fire at the back for sanitary reasons. By special flue arrangements the oven can be so constructed as to be internally heated at times if desired.

I wish also to refer to some other appliances which are not part and parcel of the oven, but which happen to have been fitted to this particular one, and which are, therefore, sketched in the diagram. These appliances I will describe under the name of heat equalising contrivances. The furnace of the oven being localised, there is, of course, a greater heat near the fire, and hence a number of devices have been employed to remedy the defect. For instance, as in the "Bailey-Baker" oven, air chambers are interposed, in which convection currents equalise the heat of the mass of air enclosed. Another type of air chamber is that in which a current of air is permitted to pass through the chamber and then cool the oven, this current of air being controlled by dampers. This arrangement is adopted in the "Mason" oven. Now, much heat traverses such chambers by radiation, that is, it is radiated from one side of the chamber and absorbed by the other, and consequently these chambers are not, perhaps, so efficacious as is sometimes supposed. Still, undoubtedly they exert a beneficial effect, and in the latter form the excess heat is withdrawn from the oven, as proved by the higher temperature of the gases which escape from the chamber. Now one of the latest and best and simplest contrivances in connection with this problem of removing the excess of heat is that which is known as Thoms's steam generator, and I wish to point out to you the principle of this particular apparatus. It consists, first of all, of a coil pipe, arranged in the case of an oven that has any unduly hot part in that particular part, or in the case of an ordinary oven which is fortunate enough to be without any unusually hot part, at the back or head of the oven. I cannot show you the coil, but you see the valve and a pipe leading from a supply cistern above. That enters and goes to the head of the oven and forms a sort of gridiron coil of pipes right against the back wall. The pipe emerges on the other side, and is there attached to a four-way valve, by means of which the steam can be directed in either of four different directions. Thus it can be injected into either of the ovens, or may be used for heating the bakery water supply, or supplying what is known as a proving press with steam. Now, if only a small current of water

Fig. 19.



Jago's Patent Oven.

be permitted to enter that coil of pipes, it emerges as steam, which can be used practically for all bakehouse purposes, giving, I find in my own experience, sufficient steam and hot water for all ordinary bakehouse purposes. One such generator in such an oven would supply sufficient, probably, for all the work done with a pair of ovens. Moderate quantities of steam can be obtained with this appliance without sensibly diminishing the back heat of the oven itself. On the other hand, if we desire to decidedly cool some portion of an oven, then by sending a prolonged current of water through the generator you find such cooling may be exerted to any desired extent. The advantage which this has is that the cooling operation does not mean actual waste, because the steam which is produced is available in the bakehouse, and can be utilised for a number of purposes. I must with this conclude my description of bakehouse machinery and ovens, and will next proceed to deal with another part of my subject.

Now, I have just to recall your attention briefly to what I have already described as the germ of wheat, being that part which constitutes the embryo or true seed. In milling, the germ is removed with the offal, because of its injurious action on the flour. Germ, in the first place, tends to cause rancidity, and in the second, because of its active diastasic power, induces objectionable changes both in the starchy and albuminous matters of the flour. Dr. Graham dealt very forcibly with these matters in his Cantor Lectures on Bread-making, and insisted on its removal from the flour. Its loss is unfortunate, because of the high nutritive value of the germ, as may be seen from the analysis appended:—

	Per cent.	
Water	12·23	
Ash	4·94	containing 2·87 per cent. of P_2O_5.
Fat	12·03	
Albumenoids	13·73	insoluble.
	15·51	soluble.
Non-albuminous soluble matters	17·79	
Cellulose	3·62	exceedingly fine and impalpable.
Other matters undetermined ...	19·15	
	100·00	

Roller milling operations separate the germ as an almost pure material, and by recently invented processes, the separated germ is subjected to the action of slightly superheated steam, its diastasic action is thus destroyed, and a specific malty flavour is developed. The germ is then mixed with the best white flour in the proportion of three of flour and one of germ, and thus is produced a very palatable and highly nutritious bread-forming meal. I have here some analyses respectively of germ and white flour compared with other products of the same wheat. The following are the figures:—

	Albuminoids. Muscle forming.	Phosphoric acid. Boneforming.	Starch.	Cellulose. Woody fibre.
Whole meal.........	14·35	0·82	70·37	3·08
White flour	13·91	0·25	71·77	0·38
Germ	33·25	2·57	—	3·62
Germ and flour ...	20·35	1·02	59·57	1·46
Oatmeal	14·29	1·03	67·10	—

Bread, therefore, from this mixture is far more nutritious than either white or whole-meal bread, and entirely free from the woody fibre of the latter. I have here a loaf of this germ bread, which I have brought in order that you may see the same, and some biscuits prepared from the same meal. This process of germ treatment is the invention of Mr. R. Smith, of Macclesfield.

I have also to refer to the fact that older works describing bread-making refer to the sodden nature of bread as the result of excessive diastasic power of unsound flours. In fact, in earlier days it was stated, when the Corn laws were under discussion, with regard to some bread, that if you took a loaf and threw it against a wall it would stick there very much in the same way as a damp snowball, through the damp, doughy condition of the loaf! I do not guarantee the scientific accuracy of this statement. One result of this condition was the use of alum to remedy the disadvantage of unsoundness. But with the advent of better classes of flour, so far is it from being the case that alum is used, that a more general complaint againt modern bread is not that the bread is too moist (and alum or anything else has to be used as a remedy), but that the bread has a tendency to dry too rapidly. Among the somewhat interesting remedies for this evil is the proposed introduction of the diastase of malt at the dough-making stage of the manufacture, and I have here some specimens of this kind. The contents of this bottle, labelled "Highly Concentrated Malt Diastase," consist essentially of a cold infusion of malt, filtered, and then concentrated *in vacuo.* If properly prepared that should, of course, contain the diastase of malt in considerable quantities, but in addition to diastase, saccharine and gummy matters, derived from the malt itself, are also present. With one and the same flour, the addition of this compound produces a moister and better flavoured bread than is otherwise obtained. Samples of bread we have placed on the table, which have been made by this process by the inventor, Mr. Fletcher, of Birmingham.

In my syllabus I have made reference to the problem of valuation of bread. Commercially, this depends on the appearance, colour, and flavour of the loaf. Within the same district a baker, on having a series of loaves placed before him, would very quickly be able to give each a comparative price indicative of its commercial value. But the standard in different localities would be found to vary considerably. In some districts the actual external appearance of the loaf weighs with purchasers much more than in others. Colour, again, has varying importance attached to it. Bread of some of the best bakers in London would, because of its dark colour, be practically unsaleable in other parts of the kingdom. Flavour probably has about equal influence on the purchaser everywhere, but this is complicated by the fact that there are most sharp and marked differences in the flavour standard of various localities. While certain people choose a sweet beer as their national beverage, others prefer a thin and slightly sour wine. Just the same differences exist in people's preferences for bread. London and the South of England choose a bread dark in colour, and in which they desire a full, sweet taste; in Scotland the preference is for a very white bread, with a slight *soupçon* of acidity. The same taste which leads our continental neighbours to drink by preference a delicate-flavoured light wine, leads them also to select delicate-flavoured white breads made from the choicest flour obtainable from the very best wheats. In consequence of these striking divergencies of taste, bread can only fairly be compared with other samples manufactured for consumption in the same districts. A London baker may or may not have an abstract opinion that Glasgow or Manchester breads may be better than that of London, but he knows that an endeavour to force these on his London customers would simply spell bankruptcy. The converse holds equally good with regard to the Glasgow or Manchester baker. It is within the province of the law to take cognisance of adulteration and fraudulent selling, but outside these the consumer is perfectly well able to take care of himself in the matter of the choice and selection of bread.

A problem of vastly greater importance is that of securing effectual control over the supply of bread to soldiers in barracks, to workhouses, hospitals, and other public institutions. In most of these cases bread is supplied by contract, the contract being given to the lowest tender in more or less open competition. My experience is that the lowest tender usually secures the contract, irrespective of the quality of bread sent in. As a result, prices are quoted which permit a profit only by the use of flours of the lowest grade, and frequently the supplying of bread of deficient weight. A good deal of this is overlooked because there is a somewhat widely spread conviction that dark coloured bread and flour are really as good and nourishing as those of better colour. This popular delusion is in this way a source of considerable injury. I do not deny that flour made from sound wheats, but containing considerable quantities of the bran ground up with the flour, may be as nourishing as the whiter qualities from the same wheat, so far as judged by mere analytical results. But I do assert, and that most strenuously, that such flours have, from their very nature, every tendency to produce heavy, sodden, and indigestible bread; bread with a coarse rank flavour, and too frequently sour. These evils are intensified by the fact that, in order to make a shadow of profit, water is added in excess in preparing the dough, and the bread is as little baked as possible. Such is the result, when it is granted that the dark colour of the cheap flour is due simply and entirely to branny particles admixed with the flour from sound wheats. But it is a fact well known to millers, bakers, and handlers of flour generally, that low grade flours are darkened not only by the bran but also by the presence of the adherent dirt of the wheat. In well ordered mills, this evil is reduced to a minimum; in the first place, the wheat is scoured and cleaned by special machinery, and, secondly, those milling products which contain dirty matters are rejected altogether from the flour, and turned into the offal. But these very cheap, low-grade flours do not all come from first or even second-rate mills. A large proportion, probably the most part, of such flours are of foreign manufacture, and are sold in this country without even the name of the miller, or the locality of the mill being known to the purchaser. But these very cheap flours are not only low grade, but are also very frequently the products of unsound and inferior wheats, badly and carelessly milled. When such is the case, the flour is far worse fitted for bread-making than even the low-grade flour from sound wheats. The evil against which I protest is the widely-spread idea—"Oh, the flour or bread may be dark, but it is so nourishing and wholesome, you know." Such flour, and the resultant bread, are revolting to the appetite, and are neither nourishing nor wholesome. To avoid misunderstanding, I must here point out that I am not referring to ordinary bakers' grades of flour, but to flours which every practical miller and baker knows as being best described by the term "cheap and nasty." The fact must be remembered that in the flour market of to-day colour is a criterion of quality, and dark, cheap flours are low in price because deficient in sterling value.

The low quality of soldiers' bread has recently received serious attention from the authorities, and it has been decided to remedy this matter by the taking of certain steps which are estimated to sensibly increase the expenditure on army bread. This matter is one well deserving of serious attention, and I venture to indicate such precautions as would, in my opinion, secure a decided and lasting improvement in army bread supply.

At the outset, a good article can only be supplied at a fair and reasonable cost, and this the purchasers must be prepared to pay, whether they are private individuals or corporate bodies. But whatever price is given, some effective system of control is necessary in order to maintain the standard of quality.

In the case of flour supply this is comparatively easy; samples should be forwarded with the tender, and these should be tested for moisture, gluten, colour, and water absorbing capacity; baking tests should also be made. When decided to whom the tender shall be given, the would-be contractor should be required to deposit a larger sample, and from time to time the flour supplied should be tested against this standard. It would be desirable, perhaps, to keep standard samples, open to the inspection of those tendering, and to require that flours submitted should be equal in quality to these samples.

In the matter both of flour and bread, contractors should be invited to send not merely their very cheapest productions, but two or three qualities, stating in each case the required price. In this way the baker would feel that not merely the price, but the price against quality of the article would be taken into consideration.

The matter of controlling bread supply is more difficult, but still is not impossible. First as to the mode of tendering. Tenders should be invited for the supply of about so many pounds weight of bread per day, baked in quartern loaves, at so much per pound, the bread to have been baked twelve hours at the time of delivery. A further condition to be laid down should be that the per-centage of moisture in the bread should not exceed a quantity which probably should be decided on from time to time. A fair limit would most likely be either 38 or 40 per cent. The novelty of this last condition might be a difficulty with many bakers, but this might be overcome by giving the information in the tender form, that so many quarts of liquor to the sack of flour would, under ordinary modes of working, yield a bread averaging so much per cent. of water. With the tender it should be required that there be forwarded sample loaves of bread, together with the flour from which prepared. The moisture in the bread should be determined, and its appearance, colour, flavour, and general properties noted. The flour should be tested as before described, and a loaf made and compared with that forwarded by the tenderer. The tender quoting the most suitable loaf at the most advantageous price having been selected, the contractor should be required to deposit a sufficiently large sample of flour to enable baking tests to be made from time to time, thus checking the supply against the original sample.

In the next place, as to delivery, this should be under the direct supervision of some responsible commissioned officer, whose grade should be sufficiently high to prevent him from levying blackmail in the form of demanding or expecting petty bribes from the contractor. Say 400 lbs. of bread have been ordered for the day; then the bread should be placed on the scale and weighed in the presence of the officer and the contractor's servant or agent, who should receive a voucher for the delivery of so many pounds of bread, credit only being given for the exact weight received. As the bread is weighed, and not the loaves counted, all encouragement to supply short-weight bread is removed. The bread should be felt in order to judge whether newer than twelve hours old; if very fresh, say only two hours out of the oven, this may be detected by plunging a thermometer into the interior of the loaf, as bread in quartern loaves takes about three hours to regain the ordinary atmospheric temperature. A loaf should at once be taken, and the water determined in a slice of the crumb weighing twenty-five grams. The apparatus necessary for such a determination is very simple, and the determination could be performed by any officer, as no special technical knowledge is required. Any surplus water contained in the bread should be debited against the account, according to a prepared table of valuations. In this manner a bread supply could be effectively checked and controlled,

It may seem formidable to require that samples shall be continuously taken and tested in the manner described; but it is only by similar systematic testing of grain and flour that private buyers see that they get full value for money expended. To secure the same object, it is imperative that a great State expenditure department should employ means of a like character. Effective control of this type would require effective organisation. Doubtless the general management of such a system of testing would have to be vested in a competent specialist, who, in addition to being familiar with modes of chemical analysis, should have had practical knowledge and experience of bakery work and direction. But there is no reason why much of the testing required should not be done locally by an officer of the Commissariat Department. The whole question of the quality of bread supply is of sufficient importance to warrant a sufficient number of officers in acquiring a technical knowledge requisite for the due performance of such tests. The apparatus required is simple, and neither extensive or expensive.

The time has now arrived when this course of lectures must be brought to a close. The great extent of the subject has necessitated its being treated in the briefest possible manner, and has prevented reference to many matters of interest. I have simply endeavoured to describe the most salient of the modern developments of bread-making, and I thank you for the kind and prolonged attention I have received. In the lapse of time, should bread-making be once more the subject of a similar course of lectures in this hall, I venture to predict that greater strides will have been made in the education of bakers, in the plant and appliances of their trade, and in the conditions under which this ancient and dignified industry is conducted, than even those which have been witnessed during the past decade.

SIXTH ORDINARY MEETING.

Wednesday, January 15th, 1890; Sir HENRY ROSCOE, M.P., F.R.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Allinson, Thomas Richard, L.R.C.P. Edin., 4, Spanish-place, Manchester-square, W.
Bartholomew, William, 82, Belvedere-road, Lambeth, S.E.
Blundstone, Samuel Richardson, 8, Catherine-street, Strand, W.C.
Coomber, Richard William, Tintern-house, Fishponds, Gloucester.
Cudworth, William, Upperthorpe, Darlington.
Davidson, Samuel Cleland, Sirocco-house, Belfast, and Killaire-house, Crawfordsburn, Co. Down.
Docwra, Colin, Old Park-house, Palmer's-green, Middlesex.
Liberty, John Barnes, 36, Belsize-square, N.W.
Liley, Henry G., Radnor-house, Radnor-place, W.
Lupton, Kenneth, Vulcan-works, Coventry.
Lye, W. T., The Firs, Luton.
Palmer, Thomas Cassinet, 121, Adelaide-road, N.W.
Seal, Stephen, Coxbench-house, Darfield, near Barnsley.
Seaton, Albert Edward, Earle's Shipbuilding and Engineering Company, Limited, Hull.
Veevers, James Mallett, Gas Works, Denton, near Manchester, and "Mayfield," Denton.
Whiting, William Henry, Fiona, Vanbrugh-hill, Blackheath, S.E.

The following candidates were balloted for and duly elected members of the Society:—

Dent, Clinton T., F.R.C.S., 61, Brook-street, W.
Furneaux, Henry John, Boxgrove-house, Forest-hill, S.E.
Higgins, Samuel, 12, Finchley-road, St. John's-wood, N.W.
Purves, David, Ferro Dene, North Dulwich, S.E.
Wright, Ebenezer, Gloucester-house, Red-hill, Surrey.

The discussion on Sir Robert Rawlinson's paper, adjourned from December 18th, was resumed.

The CHAIRMAN hoped the discussion would be kept on the lines of the paper, which had special reference to the engineering importance of the subject. As Sir Robert Rawlinson had written a short appendix to his paper, he would ask the Secretary to read it, as well as a letter from Sir Edwin Chadwick.

The SECRETARY then read the following—

LONDON SEWERAGE AND SEWAGE.

By Sir Robert Rawlinson, K.C.B.

APPENDIX.

As an appendix to my paper on the sewerage and sewage of London, I have had some tables prepared, showing the increase in population since the year 1855, when the Metropolitan Board was established. I have also prepared a table showing the current per-centage of mortality in London, Liverpool, Manchester, Edinburgh, Glasgow, and Dublin, from 1865 to 1888 It will be seen that London is proved to be the healthiest city in the three kingdoms. I have also prepared a tabulated list, setting forth the population and death-rate of London year by year from 1840 down to 1888, where it may be noted that in 1840 the population was 1,911,606, and the death rate 25 per 1,000; whilst in 1888 the population had increased to 4,282,921, and the death-rate had diminished to 18·5 per 1,000, or a reduction of 6·5 deaths per 1,000. Here is a lesson in these figures which sanitarians may study, and the grumblers over the cost of works of improvement learn to be silent. A reduced death-rate implies a much greater reduced sickness-rate, and a reduced crime-rate also. There may have been some mistakes in devising works, and some obstinacy in declining to prevent the pollution of our imperial river, but intelligence and money can rectify the engineering shortcomings; not, however, by pettifogging cheese-paring over payments to engineers. Imperial governments and local governments have strange and wild notions as to their modes of treatment and payment of professional men. If the great establishments in the country were attempted to be managed in a similar manner, it would mean bankruptcy and ruin. The new London County Council has some great and difficult engineering work before it, and it will not be made cheaper by being carried out with underpaid professional men.

I have said in my paper that the sewerage system of London is the most extensive and probably the most costly work of the sort ever accomplished, and that, grand as it is, it is not perfect. I might, perhaps, with greater propriety have said, has not been completed; and it will be in this completion—or, rather, extension—up to existing and future requirements, that great judgment and decision will be required. Look at the population of London in 1855, the date of the establishment of the old Metropolitan Board, and look at it now! In 1855, the population was 2,548,382, and now, 1888, it is 4,282,921, approaching to double. It must, therefore, stand to reason that works planned for the first period will be outgrown in a degree by the second period. The low level intercepting sewers, with their sewage-tanks and pumping stations, on the north side, from Westminster to Abbey Mills, are now too small, and will, in some way or other, have to be duplicated, and there must be additions to the south side main sewer also.

Surface or flood water and subsoil water conduits were not, in the first instance, provided of sufficient capacity; therefore, if surface and basement floodings are to be diminished, great additions must be made to the existing relief sewers and storm-water overflows. Sanitary engineering is not child's play, as the elements have to be contended with, and those only know what excesses of rainfall mean, even in this climate, who have been brought into contact with them. The world looks with admiration, and properly so, upon great admirals and great generals, and is willing that they should receive honour and reward, to be some compensation for the wear and agony of mind endured on the eve of some great battle. I can, however, in my mind's eye, see civil engineers suffering in the throes of agony and doubt over the progress of some of their works, at certain stages of their progress to completion, as Smeaton, over the first storms breaking upon his lighthouse; the elder Brunel, over the rupture to the Thames Tunnel; Telford, over his chain bridge at Bangor; Robert Stephenson, over the Kilsby Tunnel; Sir Daniel Gooch and Sir John Hawkshaw, over the Severn Tunnel; and Sir John Fowler and Mr. Baker, over the Forth Bridge. Men under such responsibilities do not always sleep soundly at night, and the engineer-in-chief who completes the metropolitan sewers, and frees the Thames from impurities, will not occupy, at all seasons, a bed free from anxiety and wearing care.

METROPOLITAN IMPROVEMENTS.

The old Metropolitan Board, in its thirty-three years of life, has carried out many improvements in London. There are the embankments on the south and north of the river; the works for the prevention of floods; the formation of new streets and various street improvements; the preparations for artisans' and labourers' dwellings; Thames crossings and freeing the bridges; building a new bridge at Putney, which is not only useful but handsome; improving and providing parks, commons, open spaces, and other works of a useful character—all these must be put to its credit. But then, all these things it was its duty to do, and it ought not to have left the one great and prime work of freeing the Thames from pollution undone.

CHEMICAL TREATMENT OF SEWAGE.

If it can ever be said that information on any subject has been exhaustively worked out it may be said of sewage, as, for the last 40 years, there has been patent upon patent, inquiry upon inquiry, and Royal Commission upon Royal Commission, and all, without exception, arriving at similar results, namely, that town sewage, in which there is the largest mixture of human excreta, and the least mixture of solid detritus, is the richest in manurial properties, and will cost the least to get rid of when applied to land in broad irrigation. The excess of water has been objected to, but seeing that water in itself is an enriching manure, this can only become a disadvantage when land for broad irrigation is not available. I have, however, indicated that on the line of the proposed main sewer outlet for the entire sewage of London, from Barking to the North Sea, there is land sufficient in area upon which to utilise every ton during ordinary spring, summer, and autumn weather, and that by reclamation of the Maplin Sands the whole volume of sewage, rain and fair, storm and calm, can be disposed of at the terminus of the conduit, and the sea be preserved from crude sewage pollution; as areas may be provided within walls or embankments for warping, when the clarified water, deprived of the detritus or sludge, may alone be allowed to pass away. And this need only occur on rare occasions, so that ultimately neither river nor sea will be polluted. I have said that sewage is not purified by chemicals, as also that the sludge separated by precipitation, in itself, has no commercial value, wet or dry, and I wish to say this again. There may, however, be persons in this room ready to declare that they can and do purify sewage, and make a valuable manure out of the precipitated sludge. My experience compels me to disbelieve such statements, and to be sorry for any purchasers of such stuff.

The only purification of sewage with which I am acquainted is when it is used in broad irrigation on a light porous soil, in summer weather, when the entire volume of the water disappears in absorption and evaporation. The soil and the sun having effectually purified it. This, and this alone, so far as I know, is sewage purification.

The following extract from the *Yorkshire Post*, 18th October, 1889, is one out of several similar cases of failure to extract profit out of sewage sludge:—

RIVER POLLUTION AND SANITARY MISMANAGEMENT AT LEEDS.—The public outcry which has been raised in the hot days of summer for many years past as to the condition of the Aire produces but little effect upon those who are charged with the health of the community. Not only has no abatement of the nuisance taken place, but as time goes on that nuisance has become intensified, and the river glides through the town charged with every abomination that domestic sewer, tannery, dyework, and factory can pass into it. But surely the Leeds Corporation has done something. Fourteen years ago the Leeds Corporation got into working order the sewage works at Knostrop, the object of which was to deal with the sewage of the borough in such a manner that a perfectly innocuous effluent was to be turned into the river, whilst the residual, it was said, was to be sold as farm and garden manure, and at such a price that the cost of the works would be but trifling to the town. But how have those anticipations been fulfilled? We have recently taken much trouble to obtain as accurate an estimate as possible of the proportion of the total quantity of the sewage of the borough dealt with at Knostrop, and in no instance is that proportion put at more than one-fourth of the whole. Leeds, therefore, sends at least three-fourths of its filth into the river just as it flows from the tan-yard, the dye-house, the chemical work, the mill, and the domestic sewer. Then the residual, does it bring in a revenue as manure? Not a penny. The Corporation are very glad to get rid of it by presenting it as a gift to farmers and market-gardeners who will take it away. Very largely, therefore, the Knostrop Sewage Works are a costly failure. How do the heavily-burdened ratepayers of Leeds like the notion of having sunk a sum of from £100,000 to £140,000, which for any practical good it has done might almost as well have been "chucked" into the Aire at once, the cost of the works in the fourteen years they have been in operation? Up to August, 1884, the sum of £57,524 had been spent upon the site and buildings. The working expenses run between £4,000 and £5,000 a year and, in 14 years will have amounted to about £60,000; and add to those items the interest on the capital sunk, and we get probably not less than £130,000 as the amount that Knostrop has cost. Against this large expenditure there is no set-off, for, as already stated, not a barrow-load of that manure which was to bring in a large revenue has ever been sold.

LONDON POPULATION AND DEATH-RATE.

Date.	Estimated No. of population.	Death-rate per 1,000.	Death-rate (average each 10 years).
1840	1,911,606	25·0	25·2
1841	1,948,417	24·1	
1842	1,992,660	23·6	
1843	2,033,718	24·8	
1844	2,075,112	25·1	
1845	2,116,830	23·3	
1846	2,158,855	23·4	
1847	2,201,175	26·8	
1848	2,243,774	25·7	
1849	2,286,635	30·1	
1850	2,329,743	21·0	23·6
1851	2,362,236	23·4	
1852	2,416,631	22·5	
1853	2,460,378	24·4	
1854	2,504,300	29·4	
1855	2,548,382	24·3	
1856	2,592,603	22·0	
1857	2,636,943	22·4	
1858	2,681,384	23·9	
1859	2,725,905	22·7	
1860	2,770,483	22·4	24·2
1861	2,803,989	23·2	
1862	2,859,734	23·6	
1863	2,904,363	24·5	
1864	2,948,963	26·4	
1865	2,993,513	24·5	
1866	3,037,991	26·5	
1867	3,082,372	23·0	
1868	3,126,635	23·5	
1869	3,170,754	24·6	
1870	3,221,394	24·1	22·8
1871	3,254,260	24·6	
1872	3,319,736	21·5	
1873	3,373,065	22·4	
1874	3,427,250	22·4	
1875	3,482,306	23·6	
1876	3,538,246	21·9	
1877	3,595,085	21·6	
1878	3,652,837	23·1	
1879	3,711,517	22·6	
1880	3,771,139	21·7	20·4
1881	3,816,483	21·3	
1882	3,893,272	21·3	
1883	3,955,814	20·5	
1884	4,019,361	20·4	
1885	4,083,928	19·8	
1886	4,149,533	19·9	
1887	4,215,192	19·6	
1888	4,282,921	18·5	

DEATH-RATE PER 1,000 IN THE SEVERAL TOWNS NAMED FOR THE FOLLOWING YEARS.

Years.	London.	Liverpool.	Manchester.	Edinburgh.	Glasgow.	Dublin.
1865	24·5	36·4	33·0	28·1	32·9	25·8
1866	26·5	41·8	31·9	27·4	29·6	28·5
1867	23·0	29·6	31·4	27 1	28·5	27·1
1868	23·5	31·0	34·3	25·2	30·7	25·8
1869	24·6	30·4	30·7	27·6	34·0	24 7
1870	24·1	32·9	29·8	23·7	29 6	24·9
1871	24·6	35·1	31·2	26·9	32·9	26·2
1872	21·5	27·1	28·9	26·5	28·2	28·5
1873	22·4	25·9	30 6	22·0	29·1	25 7
1874	22·4	32·0	31·1	23·6	31·1	26·0
1875	23·6	27·5	30·9	23·7	28·6	27·0
1876	21·9	27·5	30·2	20·5	25·3	25·8
1877	21·6	26·3	28·5	21·1	24·8	28·0
1878	23·1	29·2	29·2	22·1	24·9	29·6
1879	22·6	26·9	28·3	19·7	21·7	35·1
1880	21·7	27·1	26·9	21·5	22·6	36·1
1881	21·3	26·7	25·5	20·2	25·3	27·1
1882	21·3	26·5	26·7	19·7	25·4	27·9
1883	20·5	26·7	27·6	19·2	28·2	29·2
1884	20·4	25·2	26·4	19·7	26·9	27·5
1885	19·8	23·8	26·5	18·2	25·8	28·5
1886	19·9	23 8	26·3	19·2	25·1	27·0
1887	19·6	23·7	28·7	19·8	23·2	30·6
1888	18·5	20·3	26.1	18·0	22·1	25·3

Annual average for the twenty-four years—London, 22·204; Liverpool, 28·475; Manchester, 29·19; Edinburgh, 29·529; Glasgow, 27·379; Dublin, 27,829.

INCREASE IN POPULATION OF THE CITIES AND TOWNS NAMED BETWIXT 1831 AND 1881.

1831.	Population.
London	1,654,994
Liverpool	189,242
Manchester....................	182,812
Edinburgh	161,909
Glasgow	202,426
Dublin	185,881
Belfast	53,287
Cork	100,658
1841.	
London	1,948,417
Liverpool	286,487
Manchester....................	242,983
Edinburgh	166,450
Glasgow	274,324
Dublin	232,726
Belfast	70,447
Cork	80,720
1851.	
London	2,362,236
Liverpool	375,955
Manchester	303,382
Edinburgh	193,929
Glasgow	344,986
Dublin	261,700
Belfast	87,062
Cork	85,745

1861.	Population.
London	2,803,989
Liverpool	443,938
Manchester	338,722
Edinburgh	168,121
Glasgow	394,864
Dublin	254,808
Belfast	121,602
Cork	80,120
1871.	
London	3,254,260
Liverpool	493,405
Manchester	351,189
Edinburgh	196,979
Glasgow	477,156
Dublin	245,722
Belfast	174,412
Cork	78,642
1881.	
London	3,816,483
Liverpool	552,508
Manchester	341,414
Edinburgh	228,357
Glasgow	487,985
Dublin	249,602
Belfast	208,122
Cork	80,124

Sir EDWIN CHADWICK, K.C.B., writes:—Sir Robert Rawlinson has overlooked the fact that before the Commission of the House of Commons on the sewage of the metropolis, Mr. Moore, a practical agriculturist, on the part of a company, came with the offer of farmers of twenty thousand acres in Essex, and seven thousand acres in Middlesex, to take the sewage from the company if it were brought to them, and if the company would undertake, which they were ready to do, the application of it by their agents. Sir Robert has omitted to state the evidence of the Commission on which he served. There was evidence there of produce from sewage land, which was let at twenty-five and even thirty pounds an acre. He might have referred to the conclusions set forth by the Commissioner with whom he served, Mr. Clare Sewell Read, that sewage-farming, properly conducted, was a profitable investment. He might have referred to the experiences of Bedford, with which he had something to do, and also of Malden and elsewhere, that the yield of the sewage farms there exceeded that of the adjacent market-garden farms. These experiences, if duly examined, will be found to save all consideration of the various projects which Sir Robert recites in his paper. He might have referred particularly to the experiences of the productive power of sewage farms at Croydon, where, on land which formerly only maintained one cow, the productive power has, by the application of fresh manure, so far advanced as to maintain five; also to other evidence that sustains the general conclusions of the power of agricultnral production from liquefied-manure culture that whilst the common culture at present is as one, market-garden culture is as three and a half, but fresh sewage culture is as five. On the whole subject of the drainage of the metropolis, full two-thirds of the existing sewage is pumped in to mischievous waste in order to be pumped out again. Sir Robert Rawlinson must be aware that the reduction of that waste would effect a reduction of the whole of the intakes from the sewer-polluted sources of nearly half the metropolis, and that it is the first thing to do for the sake of economy, as well as for the sanitation of the metropolis. He mentions a provision for a general drainage as having been effected by Mr. John Roe and Mr. John Phillips. He should be aware that both those engineers were compelled to reduce their sizes by about one-half, to make them comformable in size to the experiences derived from trial works which had been directed to be made, and were made before Sir Robert's time, for house drainage as well as for sewerage, that should make all drains self-cleansing. He seems to have forgotten this, or he would not have been allowed to go on with six-inch drains for a single house, which are enough for the drainage of sixteen hundred houses. He might have mentioned, as he must have been aware of it, that the first circular earthenware drain-pipe was made by my order to Mr. John Roe. I should add, as a remembrance due to Sir Robert, that he rendered much service to German engineers on the separate system, which was partly adopted at Berlin and at Dantzic, and on examination is adopted at Paris. Sir Robert speaks of London as the best-drained metropolis in Europe. The more correct phrase would be "the least badly-drained." He must be aware of statements made in this room, that, of the first-class houses recently built, there is not above one in three free from egregious sanitary defects, whilst in houses occupied by the wage-classes, the sickness and the mortality is fully doubled by preventible causes of stagnation and putrefaction. By the rule under which Sir Robert first served, he would have been required to do work which would have reduced the death-rate by at least five in a thousand more. He should have calculated the value of five years more of life, of freedom from sickness and working disability, and how small would have been the proportion of payment from that for improved tenements. By the application of the sanitary principles under an authority which he used duly and gratefully to acknowledge, it should be remembered he did foremost work in the Crimea in saving the second army, and bringing it in a state of health which it had never enjoyed before, even at home. His zealous gratuitous services on the Indian army's Sanitary Commission have been of the highest value, in promoting the reduction of the death-rate from sixty-seven in a thousad, now to fourteen in a thousand. What he did in Lancashire in providing sanitary work for forty thousand destititute cotton-workers was pre-eminently efficient and valuable. Yet for all these great services the Treasury awarded him a retiring pension of six hundred pounds per annum—the pension of a third-rate officer under the Local Government Board. But sanitary science does not stop with any of us, not even with the old. Sir Robert may not be aware of the fact of half a million soldiers being constantly under wash in Germany, at a working expense of not more than sixpence per hundred, and that there the lowest death-rate is attained of any army in Europe. He cannot be aware—or he would have complimented me upon it—of the accomplishment of an apparatus for washing children with tepid water, in three minutes each, at a working expense of a penny for ten children; nor can he know of the reduction in the chief district schools of the metropolis of the children's diseases, chiefly by this apparatus. Nor can he know what is being done by changing air every ten minutes and maintaining it at an equal temperature. He and other old sanitary officers should go to one of our Board schools and see what is being done, and what has been done, for the reduction of the children's death-rate to about one-fourth of what it is among the general population. This is, no doubt, beside the immediate object of Sir Robert's paper. But why should Sir Robert overlook the evils caused by the sewer gas from the great man-sized sewer which pervaded the offices in which he has served, and from which he has been driven, I believe, by its pernicious influence. I have been in correspondence with the constructor of the Eiffel Tower, in Paris, and I believe the great cure may be applied there, of bringing down the air from a height and distributing it on to all the public edifices, to all the great hotels, warmed and fresh at an equal temperature; but the application of that principle for the relief of the offices of the Houses of Parliament is an advance of sanitary power which Sir Robert does not seem yet to have attained to.

Sir Robert Rawlinson said there was no man for whom he had a greater respect than Sir Edwin Chadwick, but he did not stop short of mentioning the things brought forward in the letter because he did not know them, but because the paper was not on that subject. He purposely avoided going into these questions. There was a great deal of truth in the facts put forward by Sir Edwin Chadwick, but they were entirely out of the sphere of the discussion on the paper. If he had wanted to discuss sewage farming or chemical precipitation, he could have discussed it. What he had brought forward was the fault of the Metropolitan Board of Works in not doing what Parliament intended it should do when it was created, and handing over to its successors, the London County Council, a work costing a large sum of money, which, he held, was utterly useless for the purpose of freeing the Thames, and which must be undone and supplemented by a very large expenditure in another form. That was the sum total of the paper which he had brought forward, and which ought to be discussed that night.

The Secretary then read the following letter from Mr. John Phillips:—

I should like, as the oldest living sanitary engineer of the school initiated by the veteran sanitary reformer, Sir Edwin Chadwick, to be allowed to make a few observations on Sir Robert Rawlinson's paper. Sir Robert refers to the eight separate Commissions of Sewers, formerly exercising jurisdiction in the metropolis. I may state that the present generation have no idea of the unsanitary condition of the sewerage of the metropolis half a century ago. The houses had leaky cesspools and leaky brick drains without ventilation, which emptied into leaky brick sewers, with wide and nearly flat bottoms. As the drains and sewers were many times larger than necessary, the sewage spread over the wide flat bottoms, passed away in driblets, and left the soil behind. This went on accumulating until the drains and sewers became choked, when the soil in them and in the cesspools was bucketted out and carted away. From thus allowing the sewage to flow (1) by the house drains into the surface-water drains and sewers; (2) by these into the natural water-courses; and (3) by these into the river, the latter became a perpetually oscillating body of filthy water; and its banks, owing to the sewage depositing on them at the slack of the tides, were covered with sewage-slush, where myriads of small red worms were generated. It will be seen from this how the system of removing sewage and rainfall together, in the same channels (by which the air, the ground, the water-courses, and the river became alike polluted) came into vogue. To cope with and scotch this hydra-headed monster was a fearful task. The cesspools, the drains, the sewers, the water-courses, and the river everywhere reeked with filth. But the worst of it was that what improvements were made one week were all undone by fresh acccumulations of filth the next week. By dint of sticking well to our work we succeeded in emptying, filling up, and abolishing the cesspools, flushing out all the drains and the sewers, and commenced to lay down pipe-drains in the houses, and pipe-sewers in the open ditches and water-courses, and at other places, where these could be quickly and conveniently laid. The result was, that while we cleared the metropolis of the filth—the foul gaseous emanations from which made it extremely unhealthy—we poisoned the river and made it ten times worse than before. At this there was a great outcry, which led to the main drainage of the metropolis, the result of which the Society is now discussing. In 1849, practical experience and study of this question had taught me that the combined system of sewerage and drainage was wrong, and, therefore, in that year, in my "Preliminary Report on the Drainage of the Metropolis," I urged the Commission to adopt the principle of separating the sewage from the rainfall, which could then have been very extensively carried out in the metropolitan districts. But this principle of draining and sewering towns, the new Commissioners, through lack of knowledge of the subject in all its bearings, unfortunately rejected, and the old system of polluting the air, ground, water-courses, and rivers in populous districts was allowed to go on. In my opinion, the perpetuation of this system has been a calamity, not only to the metropolis, but to the country at large. Now, however, the separate system, by which the greater part of the metropolis—as already stated—could have been drained, is adopted by the London County Conncil, and by all sanitary authorities and engineers who understand the matter. Sir Robert Rawlinson describes and condemns a tunnel sewer scheme which he says was "proposed by some influential men about 1852." I have no knowledge of any tunnel scheme other than that which I myself proposed in 1849. As, no doubt, he means my scheme, then I say that it was not—either as published or as matured for execution—as he has described it. The tunnel was intended to be laid in a uniform curve, threading the windings of the river from the bifurcation above its outlets at East Ham and Plumstead-marshes to Twickenham, and was intended to be continued thence up the valley to Windsor. It was to be a substitute for the Thames as regards an outfall for the sewage (1) of the low districts bordering the river through the metropolis, and (2) of the villages and towns on and near to the banks of the river up to Windsor. Its fall from Twickenham to East Ham and Plumstead-marshes, a length of 19½ miles, was intended to be 49·25 feet, or 1 in 2,090. As the tunnel would have been about 15·75 feet below Ordnance datum at Twickenham, its depth below Ordnance datum at East Ham and Plumstead would have been about (49·25+15·75) = 65 feet. The tunnel would have been bored nearly throughout in the impervious London clay, and not, as Sir Robert Rawlinson says, "in water-bearing strata." It is hardly necessary to state that these strata rest upon the London clay, and also at the bottom of it (at a depth of 200 to 300 feet) upon the chalk. Hence, as the tunnel would not have been bored in these strata, but in the solid body of dry clay, Sir Robert's imaginary evils, which he specially describes, could not by any possibility have arisen from it. Besides the tunnel, it was intended, by the matured scheme, to lay down from west to east through the metropolis, on each side of the river, two upper lines of main sewers for intercepting the sewage from the sewers then discharging into the river. The outlets of the intercepting sewers would have been near the bifurcated outlets of the tunnel sewer in East Ham and Plumstead-marshes. At these places pumping engines and campanile tanks or standpipes were intended to be erected for lifting the sewage from the sewers to the top of the tanks, or standpipes, and from these sets of suitable main pipes were to be laid—one set through Essex, emptying into the North Sea, and the other set through Kent emptying into the English Channel—the hydraulic head at the tanks, or standpipes, being sufficient to give the flow in the pipes a good self-cleansing velocity of 2½ miles per hour. It was also intended to allow farmers on the way to take pipes from the main pipes, as from a reservoir, on to their lands for irrigation and growing suitable crops. By this means any amount of beef, butter, milk, and vegetables of all kinds would have been raised for the population of London. This was my tunnel scheme, as matured at the time, so far as dealing with the sewage was concerned; and it is undeniable, that by it the Thames from Windsor to the Nore would have been preserved from sewage pollution; but, unfortunately for London, the Commissioners rejected it. As regards the rainfall on the metropolis, that would have gone into the river by the then existing sewers, as heretofore, after diverting the sewage from them. This could easily have been done by joining with pipes every house drain—to suitable pipes to be laid—upon or under the inverts of the sewers, and leading the pipes into the intercepting tunnel, in the low districts, and into the intercepting sewers along the higher districts, as already described. If this scheme had been carried out, the Society would not now be discussing Sir Robert Rawlinson's proposed "Sewage Conduit Scheme," as long before this the Thames would have been restored to its pristine purity, as it was in the olden time. Sir Robert Rawlinson has very kindly referred to myself in his paper, and says I "ought to have a pension." After this expression from so high an authority, he being perfectly cognisant of my antecedents in regard to improving the sewerage of the metropolis, and in doing which I spent the best portion of my life—I respectfully appeal to the London County Council, as the proper authority to grant me that aid. As referring to this, besides what I have already said, I beg to observe as follows:—Soon after I joined the engineering staff of the Westminster Commission, I think in 1843, the form and construction of the sewers then in use, and their condition, convinced me that they were unsuitable for resisting the lateral pressure of the ground, and for conveying away the sewage. In fact, it was evident that neither statics nor hydraulics had been studied in their formation. I therefore began to make experiments on the flow of sewage in the sewers, in order to find (1) the form of channel that would give the flowing sewage the utmost velocity, and (2) the rate of velocity the sewage must flow to prevent the thick heavy matter from depositing. After much time and labour I found that the channel which gave the most velocity to the sewage was the parabola, or better still, the hyperbola, and that the velocity of the flow which prevented the sewage from depositing was at the rate of 150 feet per minute. Then by combining the parabolic channel with curved basteing sides, and these with an arched crown, I got a sewer exactly the shape of an egg with the narrow end downwards.

This form of sewer the Commissioners adopted in three sizes in 1846. The next year (1847), in my evidence before the Metropolitan Commission, I first enunciated the rate of flow of sewage to prevent its depositing, namely, 150 feet per minute. Besides this, in 1848, I invented the trapped catch-pit gully, which keeps the street detritus from entering the sewers, and the noxious gases engendered in the sewers from entering the streets. That year, when I laid it before the Metropolitan Commissioners of Sewers, they readily adopted it. My egg-shaped sewer (with semicircular crown which I used in 1847) and my trapped catch-pit gully have been used ever since throughout the metropolis and the country, and everywhere abroad. My sewer superseded Mr. Roe's sewer referred to by Sir Robert Rawlinson, and Sir Robert also adopted it in his "suggestions." My non-deposit flow of sewage (150 feet per minute), engineers now use in laying down self-cleansing sewers, that rate of flow being really what makes them self-cleansing, and my proposed separate system they also adopt for sanitarily sewering and draining cities and towns. It is for a recognition of these standard improvements in sanitary sewerage and drainage I respectfully make my appeal.

Mr. CLARE SEWELL READ thought there were one or two things which Sir Robert Rawlinson put forth with regard to sewage farming, which, perhaps, required a little qualification. He quoted the value of the sewage as estimated by Sir John Lawes many years ago, but since then there had been such a cheapening of the supply of nitrates to this country, that that estimate would not hold good at the present time, when nitrate of soda could be bought at about 1d. per lb. A point greatly in favour of sewage farming was the introduction of silos. One difficulty which farmers had to overcome was to know how at particular seasons of the year to dispose of the sewage grass when there was an abundance. Farmers found that in consequence of the large quantity of grass in the market the usual customers did not want any, and they perfectly well knew that if they did not cut it, and remove it at once, the future crops would be spoilt. The invention of drying the grass did not succeed. He was positive that no sewage farm ought to be without a silo, and sewage grass made very excellent ensilage, and would produce the best possible milk without any fear of that milk being tainted. The other point referred to by Sir Robert Rawlinson was the manufacture of manure from sewage sludge, and he was very glad that the Metropolitan Board of Works were good enough to take the sludge into the sea, rather than manufacture it into manure, and sell it to farmers. No greater amount of money had been lost than in the purchase of manures made from sludge. If they were well fortified with other fertilisers, they might be a good and easy means of distributing manure over the land, but, as far as regarded the actual sludge after it was dried, it would not answer the purpose of any farmer to carry it four or five miles. He had tried the manure on one or two occasions, when a certain company was good enough to make him a present of two tons, and he unhesitatingly stated that it did no good to the crops, either corn or roots, to which it was applied. There was a good deal to be said in favour of the processes of precipitation where no land could be found for the purpose of irrigation; it was no doubt true that they deposit the solids and clarify the effluent, but beyond that they were not of much service. Therefore, whenever there was a possibility of obtaining land at a suitable price, it was very necessary that the sewage should be, if possible, applied for irrigation purposes. He was rather surprised to hear Dr. Carpenter, at the late meeting, say that there was a famine of milk in London. He thought the supply had so increased during the last three years, that the price had depreciated, and those who lived 100 miles from London did not find it within their power to produce it at the price paid them. If any one would take his milk from his cow-house twice daily, he should be glad to sell it at 6d. a gallon. That seemed a low price, but he was quite sure that by the time it reached the doors of the metropolitan consumers they would have to pay something like 2d. a pint for it. Who got the profit? Whether it was the railway company, the distributors, or the middleman, he did not know, but precious little of it came to the farmers. The idea which was prevalent many years ago that sewage was a mine of wealth had been the cause of a great deal of injury to those who entertained it and foisted it on other people. If they went on the broad principle that sewage was a nuisance which must be got rid of at any price, the sewage question would have settled itself long ago. When Sir Robert Rawlinson pointed out the fact that if you had a great conduit to take it to the Maplin Sands where you could deliver all that was not wanted into the sea; no doubt a considerable number of farmers would at certain times tap the conduit and take a considerable quantity. But they must have it when they wanted it. The great objection to sewage farming was that they had the greatest quantity when they wanted it least. If the conduit was so formed that what was not wanted could be poured into the sea, it would do a great deal of good to the neighbourhood through which it passed. The best results of sewage farming were to be seen in the immediate vicinity of the Craigentinny meadows near Edinburgh, where raw sewage might be seen flowing on to the land without any precipitation whatever. Luxuriant crops of grass were produced, and those meadows were let at a fabulous price. This illustration showed that the great thing was, if possible, to have porous land, and not to deposit sewage in tanks, but to deliver it bodily into the sea, when in the result a little profit might be obtained.

Mr. W. C. SILLAR said Sir Robert Rawlinson was well entitled to speak with authority, for his perseverance, energy, and unbounded opportunities had given him that privilege; but in proportion as a man's utterances were received with implicit faith, it was requisite that they should be free from error, and some of his most important conclusions were flatly contradicted by established facts. When Sir Robert Rawlinson conducted the investigations on which he founded his conclusions, there were four great competitors for popular favour as regards sewage disposal. First, the diversion of the sewage a little further off, which recommended itself for simplicity, provided the sea was near enough to receive it, or there were simple-minded neighbours who would make no objection, but that could hardly be called sewage treatment. Treatment proper consisted either of filtration, irrigation, or precipitation. In those days there was but one mode of precipitation, namely, by the use of lime, which had a very destructive effect, first in producing an effluent so alkaline that it was sure to set up putrefaction before two days; next, it deprived the deposit of every vestige of manurial value; and finally, it left it in a horribly offensive condition. Under those circumstances he did not think Sir Robert Rawlinson was wrong in coming to the conclusion that irrigation was immeasurably the best system; but the world had gone round since then, and what could not be done at that time could be done now, and was being done every day, as for instance at Kingston-on-Thames. Water good enough to go into the Thames above Teddington Lock was surely good enough to go into the same river at Barking Creek, or into the Clyde at Glasgow. Sir Robert had written a series of letters to the people of Glasgow, bringing forward his conclusions and summarising them in three words, in which he said, "I believe that I am acquainted with every chemical and mechanical system now in use, and I say that they are costly, inefficient, and unremunerative. I believe that no precipitated sludge is worth carrying away from the ground, and that if pressed it would not pay the expense and price of cartage." He was painfully aware that his unsupported assertion would have very little weight against Sir Robert Rawlinson's, and therefore he would ask permission to bring forward evidence to prove that he was not romancing. His witnesses were three—Wellington College, Aylesbury, and Kingston-on-Thames, these representative places showing that the system was applicable to a public institution, to a small town, and to a large one. The Bursar of Wellington College wrote, saying that the system was a complete success, the manure produced in a solid form was used on the farm, the water flowed away quite clear, and the result could not be more satisfactory from a sanitary point of view. He also said that he was satisfied that the healthy condition of the college was largely due to the efficiency of the system introduced by the Native Guano Company. At Kingston, the Medical Officer of Health to the Corporation congratulated the town and its governing body on the very satisfactory termination of their difficulties, and considered that Kingston had pioneered the way for other towns. The official report for the town of Aylesbury expressed entire satisfaction with the continued sanitary success of the process, confirming the certificates of former years, saying the effluent was sufficiently purified, and there were no complaints of nuisance. He remembered many years ago, when Sir Robert Rawlinson came to Aylesbury, he expressed his pleased surprise at what he saw, and remarked that his previous impressions of the process were mostly derived from hearsay, and turning to Mr. Harrison, who accompanied him, he said he wished they had brought some more inspectors down, and he also said that if he had prepared the report which Dr. Frankland had written, he would have done so in a very different spirit. With all that fresh in his memory, he, on a previous occasion in that room, asked Sir Robert if he could not say that the process at Aylesbury answered all the requirements of the locality, but Sir Robert replied that from his official position he thought it would not be proper for him to give a decided preference for one process over another, but that there were processes which answered all the requirements of the respective localities. The result of this was that Sir Robert Rawlinson desired one of his engineers to make an exhaustive inquiry into the system at Aylesbury. Every information was afforded to that gentleman, and he believed his report was eminently satisfactory. He remembered two things in it especially, one the report of Dr. Angus Smith, in which he said that if the effluent was allowed to go into a shallow mountain stream, it might do so without its being perceived. Then, as if trying one more means, if possible, to curse this company which seemed to militate against his peculiar prejudices, Sir Robert wrote to the Town Clerk of Aylesbury, to know if there were nothing against the process, to which the Town Clerk answered, "Our Board are perfectly satisfied with the manner in which sewage is treated by the Native Guano Company, and no allegations of nuisance have ever been made during the whole time the company were at work." He, therefore, appealed to the meeting, was he right or wrong in setting up this evidence as to the efficiency of the process against the unsupported statement of Sir Robert Rawlinson that it was inefficient, upon which assertion he based the conclusion that there was no other system than that depicted on the wall, of carrying the whole sewage of London to the sea. With regard to the value of the manure, he could also bring forward abundant evidence. He held 14 volumes of certificates from men who had bought it and paid for it, and put it on their farms, who gave the highest testimonials of the agricultural value of the stuff which Sir Robert Rawlinson and many others declared had no value whatever. He had, also, hundreds of letters received within the last two months from farmers and gardeners, all telling the same story. Sir Robert had used strong language, and said he knew he should be contradicted, as well he might. He said there were men who annually took out patents for perpetual motion; but he presumed that was the Local Government Board's polite way of saying that any man who differed from them was a fool. He said a man who could solidify sewage, and make dry and portable manure, could square the circle. There were some circles he did not wish to square — those which were called rings in the City of London; but if he meant to say that it was impossible to make portable manure from sewage, it had been done every day for the last fourteen years; and if anyone doubted it, let them go to Kingston-on-Thames, the mayor of which town was, he believed, present, and would corroborate his statement that it was made there every day. There was one kind of perpetual motion in which he thoroughly believed—the power of the earth to produce food for the population so long as they were honest enough to give back to the earth the waste when there was no further use for it. That was a completing of the circle, and that would go on for ever. There was another kind of perpetual motion which he excessively disliked, and that was the everlasting dipping the hand of the tax gatherer into the pockets of the ratepayers for the interest of money borrowed on costly and inefficient schemes of throwing into the sea what ought to go to fertilise the land. He had no objection to eminent engineers being handsomely paid, but he had a great objection to handsome engineering works being set on foot for the sake of paying eminent engineers. Sir Robert said the A B C people had been driven out of Leamington by an injunction. It is quite true there was an injunction against Leamington, followed by a sequestration, but that was against a precipitation process by lime and alumina, of which he had already spoken, which was manifestly bad; and the A B C Company was called in to supersede that, and did so most successfully. When he called Sir Robert to order for this most erroneous statement, he said that Lord Warwick told him that he intended to bring an injunction, and that they were driven out by the fear of it. It was only evildoers who were afraid of the law; the A B C Company were never afraid of an injunction, and he did not believe that Lord Warwick ever made such a statement. It only showed how ready Sir Robert had been to accept any statement against what appeared to stand in the way of the adoption of his own scheme. The whole of the manure that was made was solid, and it was not in the river. Considering how ready people were to receive calumny, he should not be surprised, if the process of the A B C Company was applied to-morrow to London sewage at Barking, to find the state of the river at once found fault with. Did anyone suppose that a sluggish stream of two miles an hour, forty-six miles long, would not deposit all the sludge in spite of the automatic arrangements? Did anyone suppose that water running over that deposit would not, by the time it reached the sea, become very stale and very offensive? Was it not possible, by the time it reached the sea, the salt water of which was of greater specific gravity than the sewage, that it would not sink but float on the top? Everyone knew there was a sickening effluvia when salt water and sewage came in contact. Would the sea bear such an abominable guest thrown upon it? Certainly not. If the sewage lay on the beach exposed to the summer sun it would fester and germinate into life thousands of bacteria, and cause an epidemic. In conclusion, he urged that what had been successful at Kingston, might be successful at Barking; but, should it not be so, as the expense of the precipitation scheme was merely the daily expenditure for labour and chemicals, the moment a better scheme was devised, it could be at once adopted. But this was not a question of daily expense; it was capital sunk in construction, and the interest of the money would remain as a perpetual load upon the ratepayers long after it was discovered to be ineffectual. The only valid excuse for such a system as that was the absence of an alternative; but, seeing that there was an alternative, he maintained that the Metropolitan Board of Works did not commit a costly blunder in making precipitating tanks, and the London County Council had done the wisest thing possible in accepting the scheme; and it would be bad policy to discontinue it until it had been given a fair trial.

Dr. A. DUPRE, F.R.S., said he passed the sewage farm at Beddington twice every day, and although during the greater part of the year it was not a nuisance, it was distinctly a nuisance on a calm warm summer's day. If that were so, a London sewage farm would simply be a terrific nuisance. With regard to the sewage farm at Wolverhampton, he might say that he had had an opportunity of inspecting that last Monday.

Sir ROBERT RAWLINSON said he did not know anything of the process used at Wolverhampton.

Dr. DUPRE pointed out that it was referred to in the paper. A strong point against sewage on farms was that it had been applied to crops for human beings, but no one would venture to feed men with things cultivated on sewage farms. It had to go first through the bodies of animals who probably, if they knew where it came from, would refuse it. With regard to the sewage farm at Berlin, he might say that that town was on a river which was absolutely useless for the disposal of the sewage. It had been tried, but it was no good; but to compare a sand waste which would take up any amount of solid with the heavy land about London sewage farms was going, to say the least, a little too far. He must protest against Sir Robert Rawlinson's statement as to the cost of the scheme of the Metropolitan Board of Works. The scheme which they adopted and nearly carried out was at an expense of about one million sterling capital, and £118,000 a year, including interest on capital, chemicals, labour, and so on; and it was not fair, in order to condemn a process, to exaggerate the expenditure three or four times. The scheme mentioned by Sir Robert Rawlinson might or might not be a good one, but it was not the scheme proposed to and accepted by the Metropolitan Board of Works. Any proposal to spend more than £118,000 was against the scheme recommended to and adopted by that Board. As the only chemist now alive who gave the Board advice as to suspended matter, he wished emphatically to protest against the statement that the Board ever denied they sent sludge into the river. He had documentary evidence to prove this. On every public occasion they stated within very narrow limits the correct amount of sludge sent in. At one inquiry they stated it was 250 tons a day; upon another, 180 tons and 207 tons, but they did not deny that the so-called sewage banks in the river were sewage mud; they contained at the most a small per-centage, and they were caused by the fault of the conservators of the Thames in enlarging the bed of the river in one particular part. Those who were responsible for the scheme accepted by the Board came to the conclusion that no precipitating process then known did receive any substantial amount of sewage matter. It clarified the water, and removed the sludge. Accepting that, it followed as a necessary consequence that a minimum amount of material which would clarify was the proper amount of material to use, both as regards expense, and the evil afterwards. It must be remembered that every grain of material added to the gallon of London sewage represented over ten tons of dry material, and over 100 tons of wet sludge per day. If instead of putting 15 or 20 grains into the gallon, only, 4 grains were used, and it clarified, that was surely an enormous gain. Then it had been stated that lime caused injury to the stream on account of it being alkaline, but it was the precise object of the scheme to limit the amount of precipitating agent, so that all of it would be precipitated, and none of it go into the river; in other words, that the effluent, although not perfectly purified, would not produce any injury afterwards to the river, in consequence of the unreasonable amount of the precipitating agent added. In the first place, by simply clarifying the sewage, it reduced the effect, roughly speaking, to one-half. In round numbers the polluting effect was reduced from 100 to about 14; or to put it differently, the polluting effect of the sewage was reduced from that of 5,000,000 people to that of 2,000,000 people. But in summer the effect was vastly greater. The resulting matter, as every chemist who had investigated the subject knew, disappeared comparatively readily, provided it had a sufficient volume of water; but the sludge matters remained in cold weather—they settled down and remained unaffected, and when the hot weather came, the river had not only to deal with the sewage then discharged, but to dispose o the sludge which had been discharged during the previous eight months. In other words, during the summer months it had to do twice the amount of work. Keeping out the sludge would therefore reduce the polluting effect to one-half: or, in other words, the sewage of 5,000,000 people so treated, as the Board of Works proposed to treat it, would be reduced in the summer to 1,000,000, or when London had reached 10,000,000 inhabitants the polluting effect on the river would be equal to that only of 2,000,000 people. When the main outfall was opened, the population of London was about 2,500,000. If the County Council was only wise enough—and he trusted they would see that they had made a serious mistake in what they did last December—to retire from the position then taken up, and to accept honestly the scheme handed down to them by the Metropolitan Board of Works, they would have by far the cheapest scheme yet proposed. He had not the slightest fear but that if the scheme were tried it would be found successful for many years to come. There were so many people who wanted to have a scheme, that they seemed to be afraid of giving a cheap scheme a fair trial, and he hoped the ratepayers of London would see that the scheme was fairly and honestly tried by the London County Council. By 1914 they might reduce the polluting effect to nothing. With regard to the effect of deodorising sewage by means of manganese, he might say that the production now was enormous, and as the price had gone down from £40 a ton without a guarantee to £8 with one, and would no doubt become a little cheaper, they might hope, with the expenditure of less money than for any other scheme, to absolutely destroy all organic matter in sewage. The scheme, which would cost £1,000,000, would effect everything, in his opinion, for the next 100 years to come.

Dr. THUDICHUM said that twenty-seven years ago he read a paper upon this subject before the Society of Arts, and as he noticed what he conceived to be several inaccurate statements in Sir Robert Rawlinson's paper, he might perhaps be permitted to point them out, so that the reader of the paper might explain them when he came to reply. Sir Robert Rawlinson said that clarification would cost certain companies which he mentioned only £100 per annum for each million, but each million per day would cost nearly 6s. 7d. He took a very much wider view of this question, and charged almost double the real expense, and he (Dr. Thudichum), as a ratepayer and scientific man, objected to that mode of putting the question. As to the amount of sludge which would be produced, the weight would average 3,500 tons per day. That derived from the sewage at the northern outfall, when sent to the sea, contained 90 per cent. of water, whilst Sir Robert Rawlinson said it was 97 to 98 per cent. These figures purported to be derived from a party working at Barking conversant with the work, but the only such persons were the superintendent and the resident chemist, neither of whom had given information to Sir Robert, and both denied the accuracy of the statement. The London sewage amounted to 272,750,000 tons per annum, and Sir Robert stated that, under favourable conditions, London could not take more than 5,000 tons of sewage per acre annually. At this rate it would require 55,000 acres of land to take the sewage of the metropolis. The late Dr. Letheby said that to be safe one could only put from 1,000 to 1,800 tons on an acre, and at that rate the London sewage farm would cover 200,000 acres, or 312 square miles, the whole area of London being only 117 miles. The scheme, therefore, for laying London sewage on a farm was perfectly chimerical. Then it was stated that a million gallons of sewage contained 150 grains of solid—a statement which it was impossible to understand, for each gallon contained from 25 to 30 grains. As regarded the sludge steamers, they were not barges, but very fine steamers of about 2,000 tons, and were beautifully appointed. He had been upon them and dined on board, and the statement that they became putrid in hot weather and required disinfecting chemicals was entirely unfounded. The statement as to the wages also was greatly exaggerated. The wages would be £40,000 per annum, not £50,000, and the expenditure on chemicals for precipitation, £20,440 per annum. The total cost of treating by the process now in use at the northern outfall, including the interest on capital, depreciation, chemicals, wages, coals, and taking the sludge to sea, would be under £130,000 per annum. This did not include deodorants such as manganate; should that be required in hot weather, it might bring it up to £150,000. Sir Robert brought the amount up to £200,000, which was £50,000 more than the actual expenditure vouched for by the documents, and then suddenly jumped to £300,000. He must most politely protest against such estimates. He most heartily concurred in what had been said by Mr. Rhodes on the previous occasion, and he hoped those who had the interest of London at heart would support the London County Council in seeing that the scheme inaugurated had a fair trial before this new plan was adopted. If the present plan failed, adopt another by all means, but they must not forget that £1,000,000 had been spent which would have to be sunk altogether, and a new plan would require £6,000,000 to carry out.

Professor CORFIELD said that though he was not present when the paper was read, he had perused it carefully, and considered it a most masterly and statesmanlike exposition of the subject. The first thing to be considered with regard to a nuisance was its removal. To get rid of it was the first thing, and afterwards you might consider whether a profit could be made of it. At the present moment, London was the healthiest city in the world, the chief reason for which was that the excreta were removed continuously, and not allowed to accumulate about the habitations of the people. It had been conclusively shown that although the sewage of London was removed from London it was a nuisance in the Thames where it was discharged, and that was abundantly proved before the Royal Commission. It now remained to get rid of the nuisance, one result of which was that no fish could live in that part of the river. As late as 1835 salmon were caught in the Thames, but none ever came up the river now. The question was, should it be got rid of by temporary expedients, or once and for ever? All schemes for treating sewage by chemical precipitation, or any way not complete, were schemes which would be shown to be merely temporary expedients, and as a rule their exponents did not maintain that they were anything else. Other capitals were not so fortunately situated as London. In Berlin and in Paris, however, they had gone in for sewage irrigation farms because they found it impossible to deal with the sewage on any other system. Here we had the opportunity of getting rid of the sewage by carrying it practically to the sea, as Sir Robert suggested, because, if the farm on which the sewage were disposed of were close to the sea, and it did not pay its expense, as had been suggested by the opponents, it would not matter, as it could be disposed of otherwise. The first thing was to get rid of it, and the problem would then be practically solved. The present London County Council, if it never did anything else than thoroughly get rid of the sewage of London in a better method than that left them by the Metropolitan Board of Works, which only consisted of discharging it into the Thames, would have thoroughly justified their existence.

Mr. ARTHUR ANGELL said he was not surprised to hear Sir Robert Rawlinson speak of the sewage being disposed of when it got to the end of his conduit, but he was surprised to hear Dr. Corfield support that view, for he could not understand anyone having a knowledge of the fact that sea water would not mix with sewage water in the same way as gases diffused, speaking as if it were the case. When millions of gallons of sewage were simply thrown into the North Sea they could not properly say that the sewage was disposed of; it was simply shifted from one situation to another. He was told he ought not to speak about sewage farms, but a great portion of the paper was made up of criticisms on them, and the bone of contention was fairly thrown down. Dr. Dupré had dealt with the one at Beddington, and he would briefly refer to one or two others. The one at Cheltenham he found from the *Birmingham Daily Gazette* for the present month, there were complaints about, and memorials were being presented against it as creating a nuisance. Croydon, he admitted, was one of the best managed, for he had never seen any other to come near it, but there the sewage was very dilute and the land well drained, but he was informed on authority, in which he had perfect faith, that a loss of £12,000 was made upon it in one year. Next he would take Harrogate, and he found from the *Leeds Mercury* that the Corporation of the town were making complaints about the pollution of a tributary of the Nidd consequent on the irrigation farm not dealing effectually with its sewage. It was impossible to imagine that with such a conduit as Sir Robert Rawlinson proposed, there would not be as much necessity for sludge-barges as at present. That, no doubt, was an engineer's question, but everyone knew that a large deposit took place where there was a sluggish flow, such as two miles an hour. Liverpool was referred to in the paper as a place where all the sewage was taken harmlessly to the sea, but his information did not agree with that. He was told by a friend of his, an eminent engineer, who had lived all his lifetime in Liverpool, that the shores of the Mersey and Dee were banks of mud, where formerly there was clean sand, owing to the vast volume of sewage that was poured into those rivers. He protested against Londoners being constantly told to go to Paris to learn how to deal with their sewage. The Paris farm was simply a chemical swindle, it was not a sewage farm at all. You might go to Clichy and see plants growing in the greatest perfection, with all their horticultural names attached, and you might see a beautiful outfall of pure water, but the sewage was delivered close by, and allowed to run crude into the Seine, where it created a fearful stench. Discussions of this kind were of very little use unless some proposal was put forward, and he would bring one forward though in only a very general form. In his belief as a chemist, it was quite possible to treat the sewage at the outfall, if they would only get away from false methods. First there was the calcomaniac age, which had been grown out of; but now there were a set of men who went in for precipitation, and that alone, and they came to grief in consequence, because where there was a large mass to act upon you needed a large quantity of reagents. On the other hand, some had brought contumely on the science by trying to use crude sewage on filter beds, but no filter beds would stand it; everybody knew it must end in a *fiasco.* There was a middle line between the two which might be carried out at Crossness by using sufficient precipitants in the tanks to coagulate and throw down the solid matter, and make some attack on the molecular constitution of the organic matter in solution, so as to make it ready to be oxidised. It would then be found that the putrescible matters were more easily dealt with by any slight oxidising powers which were brought to bear after that filtration was an operative principle, whereas before it was not. He did not consider straining through sand was filtration, for it did not affect the organic substances. According to his own experience, it would be an easy matter to drive the sludge, under air pressure, through closed mains. There was no reason why one should not be constructed from the present outfall to Canvey Island, where it might be dealt with.

Mr. Isaac Shone desired to thank Sir Robert Rawlinson for his paper, which he believed would result in a great deal of good, and especially for what he had said with respect to Mr. John Phillips, whom he had known for many years, and from whose writings he had been led to take up the study of this subject. Anyone who would refer to the transactions of the first Sanitary Commission, in 1848, would find that Mr. Phillips was really the father of sanitary engineering. Having made calculations on the data given in the paper, he could say that the figures given were perfectly correct. Taking a population of 5,500,000 the solid fæces amounted to 384 tons and the fluid to 6,140, or a total of 6,524 daily; but the sewage might be taken to amount to 30 gallons per head per day, which, with the population mentioned, amounted to 736,607 tons. The sewage proper formed only ·82 per cent. of the total volume which found its way to the outfall, which made the same proportion as putting one glass of brandy into 99 glasses of water. With regard to the plan shown on the wall, according to Cutler's hydraulic formula, Sir Robert Rawlinson was absolutely right in his statement with regard to the head of water required to send the sewage through the conduit, but it would be unwise for any engineer to devise such a scheme without providing for the maximum quantity required, and allowing for it ultimately discharging double that volume, and that would require a sewer 20 feet in diameter, which, laid at the gradient mentioned, would discharge at the rate of 30,000 gallons per head per day. But then there was the rainfall to be considered; and, with regard to the cost, he found Sir Robert referred to estimates made twenty-three years ago, and he had probably forgotten that London had increased enormously in the interval, and that the work could not be done now for the same cost. Mr. Price Williams had recently read a paper before the Statistical Society on the population of London, in which he estimated that in another thirty-six years it would amount to seven millions; and he thought, therefore, the County Council ought to prepare to deal at least with the sewage of such a population. To deliver that volume as it was delivered now would mean a stream 70 feet in width and 4 feet in depth, travelling at the rate of 150 feet per minute independent of the rainfall.

Mr. JAMES LEMON said when he came to the meeting last time he felt disposed to strongly condemn the action of the committee of the County Council, but after hearing the statement of Mr. Rhodes, he came to a different conclusion. They must consider the present situation. According to Sir Robert Rawlinson, the County Council had laid out, or would lay out, about £1,000,000 sterling for precipitation, and was this all to be thrown away without giving it a fair trial? He thought it would be very unwise to do so. He should never have proposed such a scheme himself, but there were now two points for consideration; first, the condition of the effluent as discharged into the river, and, secondly, the mode of getting rid of the sludge. Some said, why not take it down to the mouth of the Thames and throw it into the sea, but some evidence was given on that point before the Royal Commission, and there was a great diversity of opinion upon it; but some eminent authorities said that going lower down the river would not remedy the nuisance, but only alter its locality. Among those who recommended the removal there was much difference of opinion not only as to the best locality but the proper mode of discharge, most witnesses considering that, at whatever point of the estuary it was taken to, it ought to be subjected to some purifying process. If the sewage were conveyed down to the estuary it was not got rid of. Mr. Shone had very properly pointed out the magnitude of the question, and the vast bulk of the sewage, some idea of which might be gained by remembering that the outfall at the south was 11 ft. 6 in. in diameter, and that on the north there were three lines each 9 feet by 9 feet. But London was growing at such an enormous rate that an increase must be provided for, whether it was put at seven millions or a larger quantity. If a large amount of money were laid out, the prospective population must be provided for, at any rate for the time for which the money was borrowed, and it would be found that to carry the sewage of London by a conduit to the end of the river would be a gigantic operation, which those who proposed it had not, he thought, thoroughly considered. Mr. Baldwin Latham said in his evidence that it would cost £6,000,000 to convey the sewage to the estuary of the Thames; and was all that money to be spent before they had fairly considered what could be done with the millions which had been already laid out? He was not opposed to putting sewage on land, but though he had found that when it was put on high land you got proper purification, and it succeeded, when he could not get proper land, and had been forced by the exigencies of the situation, or economical reasons, to put it on low land, there was not the purification there ought to be. Low-lying land had water enough already, and sometimes more than it could do with. The effect of putting a large quantity of sewage on the low-lying lands on the banks of the Thames would be that in some parts of the year it would be filtered, but at other times it would all go into the river. He had prepared an estimate showing how the matter could be dealt with according to the present plan (which he should never have signed himself), but as it was in operation he thought it ought to be made the best of.

Mr. SINCLAIR asked if Sir Robert Rawlinson's scheme were carried out in its entirety, it would get rid of the sewer-gas which was now formed in the sewers, and was a prolific source of disease.

The CHAIRMAN said that was a question not quite within the scope of the paper.

Sir ROBERT RAWLINSON, in reply, said there was not time to answer one tithe of what had been said. He had not brought the question forward in the first instance as a chemical one, and would not attempt to go into all branches of the subject, but they had heard a long statement from Mr. Sillar, and he must say he owed an apology to him for one thing. He said that his Company was driven from Leamington by an injunction. That was a mistake, but he could rectify it by referring to a statement which gave the facts. That the Leamington Board had an injunction filed against it was true, on account of its polluting the river, and that it was suspended for a time to enable them to establish works to get rid of the sewage permanently by putting up engine power to pump it on to the land. In the meantime the A B C or Native Guano Company undertook to deal with the sewage during that interval, and they did so for some months. The result he would read from the report:—"The A B C Company carried out their process until October, 1871, and although it removed a large portion of the suspended impurities from the sewage, it, however, only took away therefrom a small proportion of the soluble polluting matters, and the effluent sewage was very little better than that which was obtained by allowing the rain sewage to settle in subsidence tanks without chemical treatment. The extraction of the sludge and drying it (especially in hot weather) in order to convert it into manure, was attended with a nauseous odour, and caused an intolerable nuisance, an intolerable annoyance to the residents of Milverton, a populous and fashionable suburb of Leamington, who made repeated complaints to the Local Board of the 'suffering they endured day and night from the offensive smell caused by the method adopted by the company for drying of the sewage mud.'" That statement was either true or not, but it was in an official report. Again, he had said that he had personally to come into contact with every sewage farm and sewage operation up to about two years ago which had been established in England, and he did say it was a most extraordinary fact that there had only been one process which had ever pretended for any length of time to make any commercial value out of the sludge. As far as he was acquainted with the operation, everyone had failed to get any value out of it, and he had in his hand the final report of the Metropolitan Board of Works of 1888, in which he found this:—"In the year 1872 the Native Guano Company were allowed to make, at the Crossness outfall, a prolonged trial of what is known as the A B C process, so called because the sewage is treated with alum, blood, and clay. The operations were, by arrangement with the company, carried on under the observation of the Board's officers, so that the Board might have full information, and be enabled to judge of the merits and commercial success of the process. The operations were continued during three months, the quantity of sewage treated being 11,672,737 gallons, about a 700th part of the sewage conveyed to the outfalls during that period. The quantity of manurial product was about 142 tons; and the cost of production was stated to be £6 6s. 4d. per ton, exclusive of rent, interest on capital, depreciation of plant, and other incidental matters. On the other hand, with the exception of a few shillings, the company's books showed no returns in the shape of sales of manure. With regard to the value of the product, the Board's consulting chemist, who made the best estimate he could on the basis of chemical analysis, placed it at 20s. a ton." That only confirmed what he said before, that making a commercial profit out of sludge had up to the present been an utter failure. It had ruined several companies. It ruined two companies at Coventry, and although they had £2,000 a year, and all that they could make out of the sludge, they had to give it up, and there were some thirty or forty acres at the outlet through which the effluent passed after it had been treated by their chemicals, and they admitted that but for that land to strain the effluent through they would have had to abandon the process altogether.

The CHAIRMAN, in moving a vote of thanks to Sir Robert Rawlinson, said they must all congratulate him on his boldness in coming as he had done into the arena, which was by no means a peaceful one. The views expressed were of a very varying character, but the only way to come to a right conclusion was to hear all sides, and he believed the result of the discussion would be satisfactory in this respect at any rate, that it had done something towards ventilating this subject, which was one of the utmost importance to the nation, concerning as it did the health of the metropolis, which was the very heart of the Empire. It was of the greatest importance that some rational and thorough - going scheme should be adopted. He was rather inclined to think with Sir Robert that the question of money was of less consequence than that of getting the work done properly. Whether it was to be done by adopting the scheme which the Board of Works had left them, or by one somewhat similar to that which had been put forward in very general terms by Sir Robert, he could only trust that the Main Drainage Committee of the County Council would undertake to do the thing thoroughly. They were there to do the work, and, as Professor Corfield had said, if they only settled that business one way or another to the satisfaction of the present and coming generation, they would have earned the thanks of the nation. He hoped the paper and the discussion would at any rate have done something to further the end they all had in view, and to free their noble river from the disgrace which now attached to it.

Mr. WILLIAM BOTLY writes that though he was not present at the reading of Sir Robert Rawlinson's excellent paper on the 18th ult., he was acquainted with most of the sewage farms referred to in the paper and in this discussion, and he considered that, whenever practicable, the solution of the difficulty is to be found in sewage farming.

Mr. FRANK CANDY writes:—Sir Robert Rawlinson's estimate, £3,244,300, may be compared with an estimate of £5,005,000 recently made on present prices. I must leave engineers to judge which estimate is the more reasonable, merely remarking that Sir Robert Rawlinson's figures as to cost are, as he admits, based upon data given in 1857—33 years ago! Taking, however, the modern estimate at £5,000,000 (some engineers put it at £6,000,000), and calculating it at 4 per cent. for interest and redemption, and 2 per cent. for maintenance, superintendence, and cleaning the canal from sludge, &c., it shows an annual expenditure of £300,000. Imagine for one moment a "new river" of London sewage starting for the sea at a considerable elevation, flowing sluggishly and in a putrescible condition through Essex for 46 miles. Will not such a river of sewage give rise to complaints? Will no injury be done to towns and villages near the coast, including such places as Southend, the Isle of Sheppy (Sheerness), Whitstable, Herne Bay, and Shoeburyness? And will the inhabitants of such places have nothing to say about emptying the London filth, so to speak, at their very doors? As to the question of getting the sewage taken in its course through the Essex marshes for purposes of agriculture, I would point to the miserable failure of the Essex Reclamation Company, who attempted on a smaller scale the gigantic scheme now propounded by Sir Robert Rawlinson. I would also recall to mind a somewhat similar scheme started many years ago at Liverpool and carried out by an eminent engineer, the late Mr. Bateman, which also ignominously failed, although the Company, finding the farmers would not purchase the sewage, offered to give it to them, when even then the agriculturists refused it, and so this scheme had to be abandoned. With such evidence before us, I do not think too much reliance should be placed on the expectation that farmers will take the sewage except in small quantities and in time of drought, and there can be no guarantee that what the farmers may take will be purified, and that some of it will not be allowed to go crude into streams and watercourses.

Mr. H. Alfred Roechling writes:—Berlin is the first large town where sewage irrigation has been adopted on a gigantic scale. When the drainage works are completed, not a particle of sewage will find its way into the river that flows through the city. Where London and Paris have failed, Berlin has succeeded. The area of Berlin comprises 24½ square miles, with a length of streets equal to 233 English miles. Its population at the last census of 1885 amounted to 1,293,920, and has increased during the last years at the rate of 3¾ per cent. per annum, the density of the population being about from 22 to 25 persons per acre. The River Spree flows through the town, and divides it into the northern and southern city, the land rising on either side of the Spree. At an average water-level the Spree discharges about 1,500 cubic feet per second, but carries as much as 5,700 cubic feet per second in flood time. The annual rainfall amounts to a little over 23 inches on an average, but the city is subject to very heavy thunderstorms. Berlin is divided into twelve separate drainage systems called "radial systems," seven lying north and five south of the Spree. Each system is entirely independent of the other, and the name "radial system" was no doubt given them, as all sewers radiate from the circumference of the system towards the centre of it, where the pumping station is situated. From here the sewage is forced through large pumping mains on to the farms. These radial systems vary in size from about 556 acres to 2,130 acres, and average about 1,150 acres, with a population, in those districts that are entirely built upon, of nearly 200,000. Only the storm-overflow sewers have a direct connection with the river, and the city authorities have to obtain the sanction of the Government for every such connections. All the systems north of the river have their farms on that side, and the same holds good of all the southern radial systems, so that, practically speaking, no sewage finds it way across the Spree. At the end of 1887, there were laid about 69 miles of brick sewers, and 255 miles of stoneware pipe sewers, and the total length of the pumping mains was about 118 miles, varying in size from 2·29 feet to 3·28 feet, the lift ranging from 50 to 120 feet. Not all the radial systems have been completed, but the town is making steady progress with them, and the authorities are determined to expedite the drainage operations as much as is ever possible. The farms in the north are about 6 miles distant from the heart of the town, and those in the south about 12 miles. The total acreage of all the farms has now reached 16,477 acres, or about 26 square miles, out of which total about 7,900 acres were, at the end of 1887, specially prepared for irrigation, and every year more land is dealt with in this way. The total dry weather sewage flow in 24 hours amounts to about 27,000,000 gallons, equal to about 21½ gallons of sewage per head, the water supply only amounting to 14 gallons. To pump 1,000 gallons of drinking water into the town costs about 7·49d.; to convey the same quantity to the pumping station, to force it from there on to the farm, and to purify it there, costs another 7·52d. The health of the labourers on the farms is very good, and the death-rate was only 11 per 1,000 during the last year; and it is a rather remarkable fact that though there was a severe epidemic of typhus abdominalis during the first months of 1888 in the town, yet no case of this disease occurred on any of the farms. The effluent from the farms goes into little streams in places not wider than 10 feet, and that from the northern farms joins the Spree above Berlin. No complaints have been raised of late about the condition of these streams, and the chemical analysis during the last year has given satisfactory results. The authorities of Berlin have spent £2,794,196 in sewage works, and £1,149,206 in sewage disposal works, or a total of £3,943,402 in the two undertakings. The income from the farms amounted during the last year to £95,027, the expenditure to £86,570, leaving a surplus of £8,457, which is equal to about 1-7th part of the total amount repayable for capital and interest. The cost of the sewage disposal on the farms is therefore about 10d. per head of the population.

Miscellaneous.

PLUM HARVEST IN SERVIA.

In the number of the *Journal* for July 26th last, p. 721, some notes appeared on the plum trade in Bosnia. The following, from a recent report on the plum harvest in Servia for 1888, will be of interest in connection with the subject. The entire production of plums in Servia during the year above mentioned amounted to 25,000 tons, of which 16,942 were exported—7,220 tons were sent from Schabatz, 4,161 from Obrenovatz, and 5,561 from Belgrade; 650 waggon loads of the above were transported by rail, and the rest by steamers to Germany, *viâ* Pesth, and to America by the Sissek-Fiume sea route. Large quantities of these Servian dried plums are exported to America direct under the name of Bosnian, which are preferred on account of their superior packing. Of these the majority are what are known as "mercantile prunes," *i.e.*, the smaller sizes in barrels; 75,000 boxes of the larger sorts were also sent to America. Great improvements in the system of drying plums in Servia are to be desired, and a profitable investment for capital might be found in this industry. The peasants are accustomed to dry their fruit in mixed masses of large and small, without taking into consideration the fact that the larger fruit requires a longer time to enable it to dry sufficiently for keeping in good condition. Packing, which plays such an important part in determining the saleable value of prunes, is also greatly neglected. The necessity for care in this respect is so well understood by Pesth merchants, through whose hands so much of the Servian fruit passes, that they pack the plums in elegant boxes, after the French style, and find an increasing yearly demand in consequence. As a rule, Servian exporters prefer to send their plums out of the country in sacks, as being easier of transport and handier for weighing purposes, and it is said that Dundee sacks (which have lost so much of the favour they formerly enjoyed in Servia for grain carrying, owing to their defective stretching) might, with a little more care, compete successfully against the Austrian in this trade.

The plums for America, which are exported in boxes and sacks, number from 65 to 130 to the kilo, and those in barrels from 130 to 140. German buyers prefer those which give from 85 to 100 to the kilo. No direct trade is done with Great Britain, who buys her Servian plums from the Pesth merchants.

Obituary.

David Adamson.—Mr. D. Adamson died at his residence, The Towers, Didsbury, Manchester, on Monday, the 13th inst. Mr. Adamson was born at Shildon, in the county of Durham, in 1818, and early in his career he became superintendent of the works of the Stockton and Darlington Railway; he was afterwards manager of the Shildon Engine Works, and in 1850 he began business on his own account. The formation of the Provisional Commitee of the Manchester Ship Canal was settled at a meeting held at his residence, Didsbury, in June, 1882, and he was the leading promoter of the scheme during its Parliamentary struggles in 1883-5. In 1887 he retired from active connection with the project, and in this same year he was elected President of the Iron and Steel Institute. Mr. Adamson was a member of the Society of Arts since 1866. He was one of the speakers at the Society's Canal Conference in May, 1888.

General Notes.

Minerals in New South Wales.—From a table published by the Department of Mines of this colony in the Annual Report for 1889, it appears that the value of the output in minerals in 1888 exceeds the decennial average value by £1,063,237. This increase is in silver coal, tin, copper, iron, antimony and silver lead ore. There is a decrease since 1887 in gold, shale, bismuth, manganese, &c.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

January 22.—R. Brudenell Carter, F.R.C.S., Vice-President of the Society, "Vision-testing for Practical Purposes." Sir Douglas Galton, K.C.B., D.C.L., F.R.S., will preside.

January 29.—Gilbert Redgrave, "The Utilisation of Blast-furnace Slag." Prof. W. C. Roberts-Austen, F.R.S., will preside.

February 5.—Arthur Paget, "High-speed Knitting and Weaving without Weft." W. Anderson, Vice-President of the Society, will preside.

February 12.—George Findlay, General Manager London and North-Western Railway, "Modern Improvements in Facilities for Railway Travelling."

February 19.—Prof. Silvanus P. Thompson, D.Sc., "The Organisation of Secondary and Technical Education in London."

Sir Douglas Galton, K.C.B., D.C.L., F.R.S., Vice-President of the Society, "The Chemin de Fer Glissant, or Sliding Railway."

G. N. Hooper, "Carriage Building and Street Traffic in England and France."

J. S. Keltie, "Commercial Geography."

J. Tripplin, "Recent Progress in British Watch and Clock Making."

Arthur Montefiore, "The English in Florida."

FOREIGN AND COLONIAL SECTION.

Tuesday afternoons, at Five o'clock:—

January 21.—John Loudoun Shand, "The Tea, Coffee, and Cocoa Industries of Ceylon."

February 18.—J. Henniker Heaton, M.P., "Ocean Penny Postage and Cheap Telegraph Communication between England and all Parts of the Empire and America."

A. Lasenby Liberty, "The Industrial Arts of Japan."

C. G. Warnford Lock, "Gold Mining in Hungary."

INDIAN SECTION.

Friday afternoons, at Five o'clock:—

January 17.—F. C. Danvers, Registrar and Superintendent of Records, "The India-office Records."

A brief account of the results of an examination, during the last six years, of the records relating to India and the East India Company now in the possession of the Secretary of State for India. LORD HARRIS will preside.

SIR J. THEODORE HOPE, K.C.S.I., "The Rationale of Indian Railways."

T. TALBOYS WHEELER, "Old Madras."

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock:—

JANUARY 28.—EDWARD C. ROBINS, F.S.A., "The Relation of the Fine Arts to the Applied Arts." WALTER CRANE will preside.

FEBRUARY 11.—W. R. LETHABY, "Cast Iron and its Treatment for Artistic Purposes."

MARCH 4.—JAMES ORROCK, R.I., "The Claims of the British School of Painting to a thorough representation in the National Gallery."

[Pictures by illustrious English masters whose works are not included in the National Gallery will be exhibited by Mr. Orrock.]

MARCH 25.—H. ARTHUR KENNEDY, "Glass Painting."

APRIL 15.—C. PURDON CLARKE, C.I.E., "Modern Indian Art."

MAY 13.—Prof. W. C. ROBERTS-AUSTEN, F.R.S., "The Use of Alloys in Art Metal-work."

CANTOR LECTURES.

Monday evenings, at Eight o'clock:—

Professor SILVANUS P. THOMPSON, D.Sc., M.I.E.E., "The Electro-magnet." Four Lectures.

LECTURE I.—JANUARY 20.—*Introductory.*—Historical. Generalities about uses and forms of electro-magnets. The magnetic properties of iron: induction; permeability; hysteresis.

LECTURE II.—JANUARY 27.—*Principle of the Magnetic Circuit.*—Experimental data. Predetermination of iron and copper for given traction. Heating of coils.

LECTURE III.—FEBRUARY 3.—*Special Designs.*—Various forms and their uses. Electro-magnets for quickest action; for longest range; for maximum traction; for minimum weight; for alternate currents; for series work; for parallel work.

LECTURE IV.—FEBRUARY 10.—*Electromagnetic Mechanism.*—Range of action of various forms of electro-magnets. Plunger and coil. Equalizers. Modes of preventing sparks.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JAN. 20...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Prof. Silvanus P. Thompson, "The Electro-magnet." (Lecture I.)
Geographical, University of London, Burlington-gardens, W., 8½ p.m. 1. Mr. E. G. Ravenstein, "Mr. J. R. W. Pigott's Journey to the Upper Tana in 1889." 2. Mr. Daniel J. Rankin, "The Mouths of the Zambesi."
British Architects, 9, Conduit-street, W., 8 p.m.
Medical, 11, Chandos-street, W., 8½ p.m.
Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. Rev. J. Neil, "Ancient Eastern Laws in regard to Land."
London Institution, Finsbury-circus, E.C., 5 p.m. Prof. R. Meldola, "Coal, and what we get from it."

TUESDAY, JAN. 21...SOCIETY OF ARTS, John-street Adelphi, W C., 8 p.m. (Foreign and Colonial Section.) Mr. John Loudoun Shand, "Tea, Coffee, and Cocoa Industries of Ceylon."
Royal Institution, Albemarle-street, W., 3 p.m. Dr. G. J. Romanes, "Before and After Darwin.—The Post-Darwinian Period." (Lecture I.)
Civil Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on Mr. George Fosbery Lyster's paper, "Recent Dock Extensions at Liverpool."
Statistical, School of Mines, Jermyn-street, S.W., 7¾ p.m.
Pathological, 20, Hanover-square, W., 8½ p.m.

WEDNESDAY, JAN. 22...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. R. Brudenell Carter, "Vision-Testing for Practical Purposes."
Geological, Burlington-house, W., 8 p.m. 1. Prof. T. G. Bonney, "The Crystalline Schists and their relation to the Mesozoic Rocks in the Lepontine Alps." 2. Messrs. Grenville A. J. Cole and J. W. Gregory, "The Variolitic Rocks of Mont Genèvre."
Royal Society of Literature, 21, Delahay-street, S.W., 1 p m.

THURSDAY, JAN. 23...Royal, Burlington-house, W., 4½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.
London Institution, Finsbury-circus, E.C., 6 p.m. Sir John Lubbock, "The Shapes of Leaves and Cotyledons."
Royal Institution, Albemarle-street, W., 3 p.m. Mr. E. R. Mullins, "Sculpture in Relation to the Age." (Lecture I.)
Electrical Engineers, 25, Great George-street, S.W., 8 p.m. Adjourned discussion on the President's Address on "Magnetism."
Camera Club, Bedford-street, Strand, W.C., 8 p.m. Rev. T. Perkins, "English Church Architecture as a Subject for Photography."

FRIDAY, JAN. 24. United Service Inst., Whitehall-yard, S.W., 7 p.m. Lieut.-Col. N. L. Walford, "The Tactics of Coast Defence." (II.) Organisation.
Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Prof. Dewar, "The Scientific Work of Joule."
Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. Thomas H. Chapman, "The Up-keep of Metalled Roads in Ceylon."
Philological, University College, W.C., 8 p.m.
Quekett Microscopical Club, University College, W.C., 8 p.m.
Clinical, 53, Berners-street, W., 8½ p.m.

SATURDAY, JAN. 25...Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.
Royal Institution, Albemarle-street, W., 3 p.m. Prof. Flower, "The Natural History of the Horse and of its Extinct and Existing Allies." (Lecture I.)

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FRIDAY, JANUARY 24, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

Professor Silvanus P. Thompson, D Sc., delivered the first of his course of lectures on "The Electro-Magnet," on Monday, 20th inst., in which he dealt with the historical portion of his subject, as well as with the magnetic properties of iron, induction, permeability, &c.

The lectures will be printed in the *Journal* during the summer recess.

EXAMINATIONS IN SHORTHAND.

In response to applications from a number of shorthand writers, a slight alteration has been made in the arrangements for the examination in shorthand, which will be held on 17th April. At this examination candidates will be allowed (if they desire to do so) to take their notes in their own notebooks, or on any other paper they may prefer, instead of on the paper provided by the Society for the purpose. These notes, however, will have to be sent in, as before, with the transcript, for the examiner's inspection. If the new arrangement should be found to work satisfactorily, it will be continued in future; if not, the old system will be again adopted.

Proceedings of the Society.

INDIAN SECTION,

Friday, January 17, 1890: Lord Harris in the chair.

The paper read was—

THE INDIA-OFFICE RECORDS.

A brief account of the results of his examination, during the last six years, of the records relating to India and the East India Company, now in the possession of the Secretary of State for India.

By F. C. Danvers,
Registrar and Superintendent of Records.

The careful custody of public records is, as has been said, an unmistakeable sign of an advanced state of civilisation. Measured by this standard, the boasted civilisation of this nineteenth century would seem to be but little in advance of what is now known to have existed in Nineveh thousands of years ago. The motives which influenced the kings of those remote ages to preserve a record of their deeds were, no doubt, of a more personal and selfish nature than such as actuate the Governments of the present day, but the results of their careful labours in this respect have proved far more interesting, important, and far-reaching than their wildest ambition could ever have hoped for. The carefully-preserved libraries at Koyunjik, which are ascribed to Sennacherib and his grandson Asshurbanipal, constitute some of the most interesting historical records extant, not the least important value of their contents being the confirmation they afford of the histories handed down to us in the Bible. These earliest records consisted of inscriptions on clay subsequently burnt. Others, as in Egypt, have been principally carved upon stone. The bark of trees and skins of animals, as parchment, cunningly-worked fibres of plants, as the papyrus and byblos, and even wooden tablets covered with a thin layer of wax, on which characters were engraved with a pointed instrument, or "style," have preserved for us records which reach back many hundreds of years before the introduction of paper.

To the durable nature of the materials used for the purpose may be attributed the existence at the present day of these records, for under no circumstances could the more perishable substances which are now almost exclusively employed exist under the same conditions. Similarly, it may truly be said of some of the earliest records of the East India Company now extant, that their preservation is in a great measure due to the excellence of the paper on which they were transcribed; and it requires no prophetic vision to enable us to assert that the materials employed in recent years, under the influence of economical motives, will require the greatest possible care in handling to ensure their existence for the use of quite an early posterity; and but for the extended use of printing and binding, the records of the latter part of the Victorian era would have but little chance of being preserved beyond a comparatively moderate number of years.

It cannot reasonably be claimed that public records are the absolute property of any generation, who are, for the time being, only trustees of an entailed estate, and it is their duty carefully to preserve that property, and to hand it down to their successors, not only unimpaired but enriched by the records of their own time.

It has been well stated by Mr. James Grant Duff, in his "History of the Mahrattas," that the "records of the East India Company's governments in India are, probably, the best historical materials in the world; there we find the reasons for every undertaking, the steady rules intended for conduct, the hurried letter from the scene of action, the deliberations of the Council, the separate opinions of the members composing it, and their final judgment. The scrutiny, censure, or approval of the Court of Directors from a remote situation, and after a long interval, bring to recollection all that was done and all that was speculated, what has occurred in India in the meantime, and what opinions have stood the test of events." It might reasonably have been expected that, with such exceptional materials at hand, the authors of histories of India would have availed themselves of the opportunity open to them of obtaining exact information for themselves at first hand; but this does not seem to have been the case. The first historians evidently wrote from very defective or incorrect information, and subsequent writers have gone on copying from one another without acknowledgment, and without testing the accuracy of the statements thus endorsed by them. Of one eminent writer in this field it has recently been remarked that his history is "saturated with party politics," and that "his want of accuracy is nothing to his bad faith." It is therefore scarcely to be wondered at that, as has been observed by an eminent Anglo-Indian, there does not exist, at the present day, "any history of British India which is trustworthy and complete in its facts, and which at the same time possesses the essential quality of literary excellence."

The materials necessary for the compilation of a history of the East India Company do, however, exist in the India-office records, and although there are some serious deficiencies amongst those of early date, they will be found to contain almost everything that might be required for that purpose, as soon as they shall have been properly classified and arranged. This is now being done, and although the work is at present only being commenced, sufficient insight has already been obtained to enable a fairly comprehensive account to be given of the extent and deficiencies of the records.

When taking in hand the classification of the India-office records, it soon became apparent that those of earlier date had hitherto been but very imperfectly catalogued; some, indeed, seem never to have been catalogued at all; whilst, in the case of others, no attempt had been made to assign them their true place in in the lists of these archives. An important step towards classifying and arranging some of the miscellaneous old records relating to the East India Company, was taken by Sir George Birdwood, in 1878, when he drew up a concise and interesting memorandum on the history of the Indian trade, and the early proceedings of the East India Company. This report has, I am glad to say, been recently reprinted, and further valuable information has been added to it by its author. To the examination then made of these old records may no doubt be, in a great measure, attributed the fact that they are still in existence, whilst the classification and arrangement then effected has proved an invaluable aid to their incorporation in proper order with the other early records still extant.

The earliest records of the East India Company date from 1596, and refer to the period immediately preceding the establishment of the Company. There are copies of two documents dated in that year; one relating to the expedition fitted out by Sir Robert Dudley and others, in 1596, consisting of three ships under the command of Captain Benjamin Wood, who took letters from Queen Elizabeth to the Emperor of China; but "not one of the company ever returned to give an account of the rest." The other is an account of the first successful enterprise of the Dutch in the Eastern seas, which was set on foot in the year 1595 by certain private merchants in Amsterdam. This latter document is from a compilation by a Committee specially appointed in 1817, just previously to closing the affairs of the British Government in Java, to examine the treaties between the Dutch Government and the Chiefs and Princes in the Eastern

Islands, from the first establishment of their connections and powers in those seas.

After this we come to the records proper of the London East India Company, and the earliest of these consist of Court minutes, the first volume of which, extending from the 22nd September, 1599, to the 10th August, 1603, was printed, by permission of the Secretary of State for India in Council, by the late Mr. Henry Stevens, under the title of "The Dawn of British Trade to the East Indies."

Of the earlier records of the East India Company there is an evident deficiency in the documents now existing. For the first few years of their enterprise they had no very efficient mode of keeping their papers, for at a Court of Committees held on the 6th July, 1607, "it was thought fit that all letters from and to India, and all answers thereof, be entered into a book and coated for future memorie as occasion may fall out;" and at a Court held on the 6th October, 1609, it was further resolved as follows:—"And for as much as it is esteemed very needfull that all letters to and from the Company, and also material writings, be coated and kept in a register ready for every occasion, and that some fitt man may be given for that business, or for any other employment of the Companie about His Maties Court or otherwise. It was now ordered and agreed that Mr. Eadmd Doe do confer and agree with some fitt and faithful man for the doeing and effecting of this, or any other the Companie's affaires wherein he shall be employed." Accordingly, on the 17th of the same month, "Ffrancis Sadler was admitted and sworn servant of the Companie for the registering of sundry letters and other writings fit to be coated, registered, and kept for the use of the Company. And further to doe such other their services upon which they shall think good to employ him." Mr. Francis Sadler was not, I am afraid, a good record keeper, for in 1614, "certain journals" were wanted which could not then be found, and it was consequently ordered that all journals should first be written in the Company's books before being lent to any man, and that none were to use them without the consent of the Committees. The missing journals, which had been lent and could not be found, were to be searched for. Some months later, in August, 1615, a further resolution was passed that none of the Company's journals were thereafter to be lent "before copies of them be entered in their books, whereby the journals themselves have been lost to the great prejudice of the Company, and some things known which are not fit to be published." After being entered they were to be "delivered only to some principal persons of the Company that shall desire the same;" but all other persons wishing to inspect them were to be "satisfied with coming and seeing them in the office, or otherwise a copy of them in the books." In 1618, Mr. Ellam, a book-keeper in the Company's service, who appears to have also had charge of their records, was "ordered not to allow any letters or journals to be carried out of the house without special permission, but those belonging to the Company to have leave to read them in the counting-house."

It will thus be seen that precautions were, from time to time, taken to prevent the loss of their journals and other records; but notwithstanding all that may have been done in that direction, it would seem that, at a later date, when the union was effected between the "London" and the new, or "English East India Company," the records of the former were found in great disorder, and many were missing, for there exists a notice, without date, to the effect, "that at the dissolution of the Company, meaning when the Old (or London) was absorbed in the United Company, great numbers of their books and papers were promiscuously put together, some of which have since come to the Trustees' hands, and more are inspecting by 'their register,' in order to obtain the necessary information for answering Plaintiff Yale's Bill, and that it will require a deal of care to separate and digest them."

In 1830 or 1831, an attempt was made to collect all the original correspondence from India, with collateral documents, originating at any places between England and Japan, which were then extant, and as a result some 8,500 papers were arranged and bound in 72 volumes. These extend from 1603 to 1708, and correspond to the volumes of letters from and proceedings of the Governments in India of the present day. In the first volume of the catalogue to this collection is a memorandum of the various old catalogues from which the revised catalogue of original correspondence from India was formed. These are as follows, with their abbreviated titles:—

O.C.—Original correspondence, chiefly letters from India.

App.—Miscellaneous papers appended to O.C.

D.P., I. II. III.—Damaged papers: first, second, or third list.
Dom.—Domestic papers, improperly mixed with some from India.
I.P.—Imperfect papers.
F.P.—Foreign papers.
I.L.—Indian letters. Another series from India.
Law.—Four subdivisions. Among them many political papers from India.
P. 14 C.—Papers from fourteen chests.
W.P.D.—Without proper date. The dates to most of these have since been supplied.
Supp. to W.P.D.—Supplement to the last.
Acc.—Accounts.

From the foregoing it would appear that at the above-mentioned date the confusion into which the earlier records of the East India Company had been permitted to fall could hardly be surpassed, and it is clear that, for some reason or another, the whole of the papers comprised in these several catalogues were not then included in the new collection, as several bearing identically the same titles have since been discovered and included in the list of miscellaneous old records reported on by Sir George Birdwood in 1878.

The basis of this series—known as the O.C. Records—consists of original letters dated in India, extending to all places within the limits of their charter, which letters are either addressed to the Company or were interchanged between the Company's factories in Asia, or with native or European correspondents. "They seem," it is stated in a note, "from what materials were extant at the commencement of order in keeping the early Records, to have been preserved by accident. The series, though valuable and important as far as it extends, is not continuous."

Up to 1830, the deficiencies in the records had probably been caused either by accident, carelessness, or unforeseen circumstances; but it is to be feared that other deficiencies have been the result of deliberate destruction without due care and discrimination. In 1858, the then Registrar brought to notice that there existed a quantity of miscellaneous papers belonging to the secretary's office which had been accumulating for thirty years, "which neither are, nor ever could be, of any use whatever," together with "a quantity of warehouse books and documents of a miscellaneous character, such as sale books, appearance books, catalogues, &c., not any of which have been referred to during the past twenty years." These were accordingly ordered to be sold, and over 21 tons of documents were disposed of as waste paper, and realised £158 0s. 10d.

It will be observed that this accumulation had been going on from about the period of the "Revised Catalogue of Original Correspondence," and that the spasmodic energy which, in 1830, resulted in the preservation of priceless historical records, in 1858 counselled destruction. And, with regard to the Registrar's arguments for disposing of the papers, &c., then sold, it may be observed that if all documents not referred to for twenty years were deemed only fit for destruction, many of the national historical records would unquestionably soon disappear from the public ken.

It is not improbable that some volumes, and particularly papers not bound, may have been lost in the removal of records from one place to another, and the greater part of them have been removed no less than three times, and some of the earlier ones more often still. At the time of the Great Fire of London in 1666, fifteen loads of goods, comprising treasure, books, papers, &c., were removed from the Company's offices to Stepney and Mile-end, and were brought back as soon as the danger had ceased to exist; and a further removal must have taken place at the union of the two Companies. In 1859, in consequence of certain warehouse room in New-street, in which the bulk of the records was then kept, being required by the Storekeeper-General, thirty-one cartloads, comprising in all about 20,000 volumes, were removed thence to the cellars in Leadenhall-street, and in the same year there was a further sale of nearly two tons of documents as waste paper.

In February, 1860, Sir Charles Wood, then Secretary of State for India, gave directions that all useless records in the India-office in Cannon-row, and in Leadenhall-street, were to be destroyed, or otherwise disposed of, previously to removal to the building rented in Victoria-street, Westminster, for an India-office. For this purpose, a committee was appointed, in accordance with whose recommendations orders were issued for the destruction of an enormous quantity of books and papers, amounting altogether to upwards of 317 tons, which were sold as waste paper, and realised £3,095 16s. The destruction of this enormous mass of records was to a great extent due to the circumstance that duplicate copies of most documents existed, subsequently to 1784, the one being in Leadenhall-street, and the other in Cannon-row, and that on the amalgamation of these two offices it was not necessary to retain more than one copy for official use.

In 1867, on the removal from Victoria-street to the present offices, a further destruction of books and papers took place, also on an extensive scale; and in 1877 and following years selections were made by the Department responsible for the custody of the records, of papers, books, and documents which it was considered might be safely destroyed, and these were in each case confirmed by Council authority before being acted on. It is much to be feared that in the endeavour to get rid of only useless records, those destroyed, especially in the earlier years of destruction, had not been sufficiently examined before being condemned, and that thus documents of great historical interest shared the fate of others which had ceased to possess any sufficient value to justify their preservation. The destruction of really useless documents has recently been reduced to a system, and so long as this remains in force, there is no fear that any more valuable records will be sold as waste paper.

Having given a brief account of the destruction and loss, from time to time, of valuable historical records, it is time to turn our attention to what now exists, and in doing this it will be desirable to deal with the earlier papers apart from any special classification, except so far as the following division into periods is concerned.

The records at the India-office admit, for the purpose of the present paper, of separation into three distinct periods, viz:—(1) The early attempts of the East India Company to establish and maintain a monopoly of the trade with the East, extending from the 22nd September, 1599—on which day a number of gentlemen met, and together subscribed a sum of £30,133 6s. 8d. towards "the pretended voiage to the Easte Indias"—to the 18th April, 1710, on which day a General Court of Proprietors was held to elect directors for the United Company, in accordance with the charter of the 22nd April, 1709, for the union of the London with the English East India Company. (2) From the 18th April, 1710, to the 22nd April, 1834, at which latter date the trading operations of the East India Company were brought to an end, in accordance with the terms of the Act 3rd and 4th Will. IV., cap. 85, under which statute also all the real and personal property of the Company was to be held in trust for the Crown for the service of India; and (3) from the last-mentioned date to the present time.

It has been customary to date the commencement of the English trade with India from the beginning of the 17th century; but this is by no means correct. The first direct trade of eastern produce to England was conducted from the Levant, whither, so early as the years 1511 to 1534, ships used to sail from London and Southampton, and whence there was "an ordinarie and usual trade to Sicilia, Candie, Chio, and somewhiles to Cyprus, as also to Tripolis and Barutti into Syria," whence they brought back, besides other merchandise, "pepper, cinamon, and some other spices," thus unmistakeably showing that they obtained a portion of the then existing Indian trade. This trade was carried on until 1550, after which date, however, it appears to have been entirely discontinued; but about the year 1575, Sir Edward Osborne and Mr. Richard Staper endeavoured to resuscitate it, for which purpose they sent out Mr. Hareborne to Constantinople, who succeeded in obtaining privileges from the Grand Turk, in consequence of which, Queen Elizabeth, on the 11th September, 1581, granted letters patent to Sir Edward Osborne, Thomas Smith, Esq., Richard Staper, and William Garrett, for their trade into the dominions of the Grand Turk. The new Levant or Turkey Company attempted to open an overland trade to the East Indies, and sent merchants, with cloths, from Aleppo to Bagdad, and thence down the Persian Gulf; these having obtained articles at Agra, Lahore, Bengal, and even at Malacca, on their return to England brought information of the riches to be acquired by a trade to the East Indies. In 1591, the same Company fitted out three ships for a direct voyage to India, only one of which, however, reached its destination, and that was lost on its return home. Two years later, this Company obtained a new charter, whereby they were empowered to trade to India overland, through the territories of the Grand Seignior. Of the promoters of the Levant or Turkey Company we find that Sir Thomas Smith, then Governor, was also first Governor of the East India Company, and there is no difficulty in identifying this Sir Thomas Smith with the Thomas Smith, Esq., above mentioned; Mr. Richard Staper was also one of the first directors, and took a very leading part in the affairs of the East India Company; and we are, therefore, I think, justified in assuming that these gentlemen took an active share in, if they were not indeed the actual promoters of, the establishment of the East India Company, which would thus seem, in a sense, to have been an outgrowth of the Levant Company. This is further borne out by the fact that at the end of the first volume of court minutes are copies of several letters sent to Constantinople by the Levant Company.

As has been already stated, there are considerable and serious gaps in the early records of the East India Company. Amongst the minutes of the proceedings of the directors, what ought to have been volumes 2, 4, 6, 8, 10, 16, and 18, besides some few of later dates, are missing; but at some subsequent period those remaining have been rebound and numbered consecutively, and in consulting them it is therefore necessary to bear this fact in mind, and to carefully observe the dates rather than the numbers of the volumes. Those who have been in the habit of consulting records of three hundred years ago, will be aware of the fact that the change in the year dated from the 25th March, which was then the beginning of the new year, and that the alteration to the 1st of January only took place from the year 1752, in accordance with Act 24, Geo. 2, cap. 23. It is stated in a publication of one of our learned societies that the first expedition of the East India Company "sailed from Woolwich on the 13th of February, 1600." This is, no doubt, technically correct, but as it appears, from the Court Minutes, that the several vessels for that expedition were only finally selected on the 8th of October, 1600, the fleet really sailed on the 13th of February, 1601, according to the present mode of reckoning the year. The Company did not at first trade with India proper at all, but went direct to Malaysia in search of spices, which constituted then the principal article of trade from the East. Captain Lancaster, who commanded this first expedition, sailed straight to Sumatra, and having secured certain privileges of trade at the port of Achin, proceeded to Java, and opened a trade at Bantam. For some time the Company's merchants conducted their trade by means of barter at the several ports where they called, but subsequently they established factories at different places, where agents were left in charge to prepare cargoes for the ships when they returned. Owing to the primitive method of conducting business, there could not have been any very extensive correspondence between the Directors of the Company and the captains of their vessels, and this fact renders the logs and journals of the latter of the greater value and importance. Unfortunately, however, many of the earliest of these "Marine Records" are missing, and their loss is only partly compensated for by the publications contained in "Purchas, his Pilgrims" and those of the Hakluyt Society. It appears that Mr. Hakluyt was consulted by the directors of the East India Company from the very commencement of their operations, and he was subsequently appointed "Historiographer of the Company," in which capacity he seems to have been entrusted with the custody of the manuscript journals of all the East India voyages from 1601 almost to the date of his decease in 1616. It is probable that these subsequently came into the hands of the Rev. Samuel Purchas, who, in the introduction of his work, admits having received "Master Hakluyt's many yeeres collections and stocke of written papers," and it appears from Court Minutes of 27th February, 1622, that Mr. Purchas was to be allowed to see the Company's journals of voyages unto the East Indies, particularly the journal of Sir Thomas Roe, but is to take nothing but what "is proper to history and not prejudicial to the Company;" his notes also were to be perused before being carried out of the house. This caution was probably due to the circumstance that the journals formerly in the possession of Mr. Hakluyt had not been returned; but notwithstanding the care then observed, Sir Thomas Roe's journal has disappeared from amongst the records of the India-office. There is now in the custody of the British Museum a manuscript entitled "Journal of Sir Thomas Roe, 1615," which was purchased at the Arley Castle (Staffordshire) sale in December, 1852. This, however, consists of only 33 Folios, and is evidently not the complete journal. It appears also, from "Churchill's Collection of Voyages" printed in 1704, that at that date the journal of Sir Thomas Roe was, together with a vast multitude of letters contained in two volumes relating to "business of trade as directed to the several factories in those parts and to the East India Company in England," in the possession of Messrs. J. and A. Churchill, booksellers, and that Sir Thomas Roe's journal was not even then complete. From a comparison between the published journal and that at the British Museum, it seems pretty certain that the latter is not the same one that was in the possession of Messrs. Churchill.

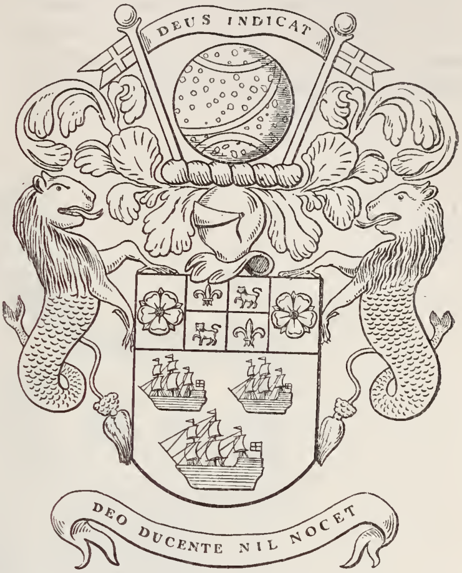
I recently discovered, in the library of the Intelligence Branch of the War-office, a copy of Captain Saris's "Journal," the original of which has long since disappeared from its proper place at the India-office. Captain Saris commanded the eighth voyage set forth by the East India Company, which sailed on the 18th August, 1611, and was one of considerable public interest, as that officer was the first to establish a trade and an English factory in Japan. It appears that this document was purchased by the War-office in 1857, together with other documents, from the executors of the late Colonel Jervis. By the courtesy of the present Secretary of State for War, this valuable document is now in its proper place amongst the India-office records. In July, 1886, a gentleman into whose possession had fallen the diary of Mr. William Hedges, the first agent and governor for affairs in the Bay of Bengal, dated between the years 1681 and 1688, very generously presented it to the India-office records, that being, as he then stated, "its appropriate resting-place." This has since been edited by the late Sir Henry Yule, for the Hakluyt Society. It is possible that, in course of time, other valuable documents, now missing, will be traced, and perhaps the best chance of attaining this end would be secured if the press would notice the desire that now exists to make the India-office records as complete as possible. Even if documents that may have changed hands several times since they were sold as waste paper, or otherwise removed from the proper place of their custody, may not now be procurable for the India-office collection, it would yet be a satisfaction to know where they are, and that in the interests of students in this branch of history.

One of the early objects of the East India Company was to possess a coat of arms, and by an order of the Court of the 1st May, 1601, we find a warrant was given to their treasurer "to paye to the Kynge of Heraldes the some of Twentie merkes for assigninge a Armes to the Companie by vertue of his Office." This coat of arms is shown in Fig. 1. It has been enlarged from a stamp on the cover of one of the old Court books. I have also verified it at the College of Arms, and have to record my acknowledgments to Sir Albert Woods for the following description in heraldic phraseology:—

Arms.—"Azure three ships Or, all under sail; garnished with crosses, Gules, and upon a chief Or between two Roses Gules, an additionment out of the arms of England, viz., quarterly Azure Gules, in the first and last a lis Or, in the second and third a lion passant guardant of the same."

Crest.—"On a wreath a sphere or globe celestial between two Standards of St. George; as supporters, viz., two sea lions Or, Azure, mantled Gules doubled Azure. Motto: 'Deus Indicat' over the sphere. Motto under the coat 'Deo ducente nil nocet.'"

FIG. 1.



FIRST ARMS OF THE EAST INDIA COMPANY.

It was ordered by Court Minute of the 29th December, 1600, that the "goods shipped by the Company and the Caske shal be marked with this genall marke in the mergent." This mark was varied slightly in subsequent years, as shown in the illustrations.

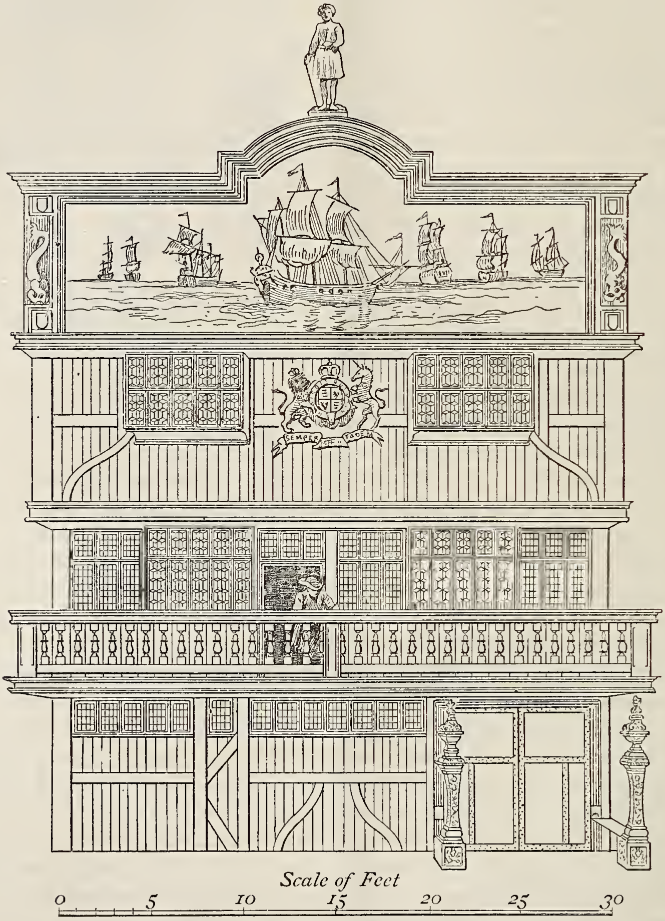
Fearing opposition from the Spanish vessels, the Company had postponed their first voyage for twelve months, hoping in the meantime that a treaty of peace would be concluded with Spain. In 1601, the Company were granted letters of reprisal, authorising them to capture Spanish vessels, and in consequence of the opposition to their trade by the Cape, from both Dutch and Spanish ships, they, so early as July, 1601, determined to send out expeditions for the discovery of a north-western passage to India, regarding which there exist still some important and interesting documents.

Up to 1608 the Company had traded only to Java, Sumatra, and other Eastern islands; but their attention having been directed by their agents at Bantam and in the Moluccas to the fact that the cloths and calicoes imported from

Cambay were in great request there, they despatched their fifth voyage to Surat and Cambay, and thus commenced a commerce with India proper. Soon after this Surat became their principal seat of trade there.

From a paper by Sir Jeremy Sambrooke, accidentally preserved amongst a mass of loose documents, it appears that the Company's first and second voyages realised a profit of 95 per cent., and the third voyage one of 234 per cent. After this the profits varied from 87½ to 220 per cent. until the year 1617, when, owing to the systematic opposition of the Dutch, they fell to 12½ per cent., which was a rate no doubt hard to be borne by the shareholders in those days, but would gladly be accepted at the present time upon as good security as they then enjoyed.

FIG. 2.



OLD EAST INDIA HOUSE IN LEADENHALL-STREET.

The earliest document from abroad now extant relating to the East India Company's business, is a translation of the Articles granted by the King of Achin to the subjects of the Queen of England for free entry and trade, duty free, without regard to the goods imported or exported. This was probably one of the earliest documents received from abroad as being the most important result of the first voyage. It is, however, clear that at one time there were in existence at least thirteen earlier documents, as this—although it now appears as the first of the O.C. records—bears also No. 14 at the bottom of the page, clearly indicating that it was at one time the fourteenth document of some earlier collection. Similarly, what is now the sixth document in the book also bears the number 139A.

The original charter, granted to the East India Company by Queen Elizabeth, gave them the entire and exclusive privilege of trading to the East Indies for a term of fifteen years, and all other the Queen's subjects were prohibited from any interference with them, except by the Company's licence. The original of this interesting document has long since been missing from the archives of the India-office, and it is not known whether it be still in existence. In violation of this charter, King James, in 1604, granted a licence to Sir Edward Michelborne and others to trade to the East; but, in 1609, on an application to the King, the Company was granted (31st of May) a confirmation of their rights, and to possess "the whole, entire, and only trade and traffic to the East Indies, for ever." This also is missing, and it seems not improbable that these charters were surrendered when new ones were granted, confirming or extending the privileges granted by those of earlier date. During the 17th century a number of charters were granted for various purposes, the most important of which were—(1) The grant of the Island of Bombay* to the Company by Charles II. (27th of March, 1669); (2) the grant to them of the Island of St. Helena, also by Charles II. (16th of December, 1674); and (3) the authority to the Company to coin money at Bombay (5th of October, 1677).

The first factory established by the Company was at Bantam, and they soon spread their operations over the neighbouring islands. On the third voyage a visit was paid to Amboyna for the purchase of cloves. A little later they took possession of Polaroon and Rosengin, but the animosity of the Dutch raised every possible obstruction to their successful trading. The English and Dutch Companies levied war upon one another in these parts, which state of things culminated in the massacre of the English factory at Amboyna, on the 27th February, 1623. By this time the Company had established factories at Achin, Tiku, and Priaman, in Sumatra; at Bantam and Jakatra, in Java; at Sukadana and Banjarmasin, in Borneo; at Amboyna, Polaroon, Rosengin, and Macassar; also in Siam and at Patania on the Malay Peninsula; at Firando in Japan; whilst in India they had a factory at Surat, with subordinate agencies at Gogra, Ahmedabad, Cambay, and Ajmir; and factories at Calicut, Cranganore, Patna, Agra, and Masulipatam; whilst in a more westerly direction they had established themselves at Jask and Ormuz in the Persian Gulf, and at Mocha in the Red Sea. In making these last-named acquisitions the East India Company clearly recognised—what had at an earlier period been discovered by the Portuguese—that if they desired to obtain a monopoly of the Indo-European trade they must be in a position to dominate, if not to destroy, those branches of it which passed respectively by way of the Red Sea and the Persian Gulf to the Mediterranean ports.

Notwithstanding its exclusive privileges, the East India Company was not permitted to pursue its trade to the East uninterruptedly. In 1635, Courten's Association obtained a charter from Charles I., under which they settled agencies at Goa, Baticola, Carwar, Achin, and Rajapore, and this had the effect of greatly depressing the trade of the former Company, until at last, in 1649, the two Companies were united. About this time also, other opponents came into the field in the shape of a French East India Company, which, however, effected little for some years, and it was not until 1668 that the first French factory was established in India. This was at Surat, and in 1673 they effected a settlement at Pondicherri.

In the early days of trade with India it seems to have been customary to send home two copies of letters by different routes; the originals appear generally to have been sent by ship, whilst duplicates were transmitted via the Persian Gulf and Aleppo. Unfortunately, in a great number of cases, the duplicates have been preserved and the originals lost or destroyed. As giving some idea of the curiosities contained in the records of this early period, I may instance that in 1675 the skeleton of a mermaid was sent home, which the Court presented to His Majesty.

Towards the end of the 17th century the Company had been trying hard to get their privileges confirmed by the House of Commons, as a resolution had been passed by that body in 1693 that it was the right of all Englishmen to trade to the East Indies, or any part of the world, unless prohibited by Act of Parliament. The Company therefore proposed to advance £700,000 at 4 per cent. interest for the public service on condition of their privileges being confirmed by Parliament, but were outbid by a number of merchants who offered £2,000,000 at 8 per cent. provided they might have the exclusive trade to India invested in them, and should not be obliged to trade as a joint stock unless they should afterwards desire to be incorporated for that purpose. The original list of subscribers to the above amount is still in existence.

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* The Island of Bombay was ceded by the King of Portugal by treaty of the 23rd of June, 1661, to King Charles II., who transferred it to the Company to be held in free soccage, as of the Manor of East Greenwich, on payment of the annual rent of £10, on the 30th September yearly, for ever.

At a Court of Directors of the new Company held the 8th November, 1698, at Mercers'-hall, two months and three days after its formation, a disposition was expressed to agree to a union with the old Company upon reasonable terms; and upon ascertaining what proposals the old Company will make, "this Court will then endeavour to gett a full authority to treat with them in order to attain a happy conclusion."

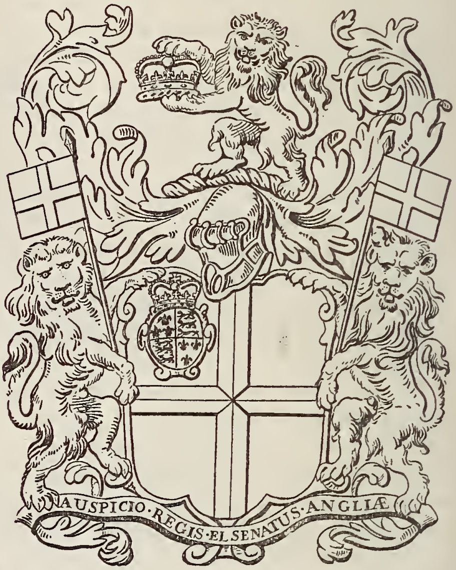
Accordingly an agreement was come to about the beginning of 1702, the terms of which were embodied in three deeds, all dated the 22nd July of that year. The several charters and deeds by which this union was effected, dated in 1708 and 1709, are still in existence.

Very little now remains of the records of the new or English East India Company. Indeed, as yet I have only been able to find two books, in one of which the following curious statement occurs:—"At a Court of Directors held at Skinners'-hall on Wednesday, the 19th April, 1699, the Court was informed that there are engines and paddles to move ships when they are becalmed, and it was moved that one might be sent at the Companies' charge by the 'Gosfreight' or the 'Rook.' Ordered—That one of the said engines be provided by Mr. Shepheard upon the Company's account."

Until the completion of the union between the two Companies, each Company conducted its own separate business, besides which a joint committee of the two Companies was formed entitled the "Committee of Managers." There are four volumes of the minutes of proceedings of this joint committee, extending from the 31st July, 1702, to the 13th April, 1709. The first Court of Directors of the United East India Company was held on the 19th April, 1712, at which date the union may be said to have been completed. With this union a change also came over the character of the Company itself. Up to this time it had established factories and developed trade throughout the East; now it was destined to enter upon a period of conquests. Before this date it had added materially to the wealth of the nation, by increasing its commerce; but it was now—as stated in its motto, "Auspicio Regis et Senatus Angliæ"—to add to its political importance by an increase of its territorial possessions.

The O.C. collection contains letters and proceedings relating to all the Company's factories, but from most of them there exist other documents, some of striking interest. Particulars relating to some of the minor factories will be found principally in the proceedings of those to which they were subordinate. Thus, in the records from Bantam or Batavia, Surat, Bombay, Fort St. George, and Calcutta—each of which at one time or another became the chief presidency town—will be found particulars of all the minor factories, in addition to which, however, many of the more important of these latter seem to have also corresponded direct with the Court of Directors, and to have sent home to them copies of their proceedings. These direct communications, though sadly defective, are, it is believed, sufficient to enable a fairly complete history of each even now to be compiled. The following is a list of the Company's several factories; an asterisk denotes those concerning which separate records are now extant:—

FIG. 3.



ARMS OF THE UNITED EAST INDIA COMPANY.

- *Bombay.
- *St. Helena.
- *Surat.
- *Swally.
- Broach.
- Amadavad. (Ahmedabad)
- Agra.
- Lucknow.
- Carwar.
- Tellicherry.
- *Anjengo.
- Calicut.
- Persia—
  - *Gombroon.
  - Shiraz.
  - *Ispahan.
- Chingee.
- Orissa.
- *Fort St. George.
- *Fort St. David.
- *Cuddalore.
- *Porto Nuovo.
- *Pettipollee.

*Metchlipatam.
(Masulipatam)
*Madapollam.
*Vizagapatam.
Sumatra—
*Fort York.
(Bencoolen)
Indrapore.
*Tryamong.
Sillebar.
Cochin China—
Tonquin.
Bengal—
*Fort William.
*Chuttanuttee.
(Calcutta)
*Ballasore.
*Cossimbazar.
*Dacca
*Hughly.
*Maulda.
Rajamaul.
Patna.

The above were handed over by the London East India Company to the United Company at the union of the former with the English East India Company. At the same time the latter handed over the following factories which they had established, viz. :—

Surat.
Bengal.
Metchlipatam.
Madapollam.
Borneo.
Pulo Condore.

The following places had by this time, for one reason or another, ceased to be occupied by the London East India Company :—

*Borneo—
Sukadana.
Banjarmassin.
Java—
*Batavia.
*Bantam.
Jakatra.
*Amboyna.
Sumatra—
*Jambi.
*Achin.
Tiku.
Priaman.
China—
*Amoy.
*Tywan.
*Macao.
*Canton.
*Japan—
Firando.
Polaroon.
Rosengin.
*Siam.
Malay Peninsula—
*Patani.
*Macassar.
*Golconda.
*Engleswad.
*Conimero.
*Pulicat.
*Armagaon.
*Tanjore.
Gogra.
Cambay.
Ajmir.
Cranganor.
Patna.
Jask.
Mocha.

We now come to the second period of record classification, viz., from the union of the two Companies to the abolition of their charter for trade. The old Company had, indeed, been absorbed by the new, whose charter entitled them to the exclusive trade with India until the expiration of three years' notice after the 29th September, 1711, and this was subsequently extended in 1712 (10 Anne, c. 28) till the expiration of three years' notice after the 25th March, 1733, and in 1730 this period was further advanced (3 Geo. II., c. 14) to the 25th March, 1766. These advantages were not obtained without, in each case, a pecuniary consideration to the benefit of the State. By a charter of the 24th September, 1726 (13 Geo. I.), municipalities and mayors' courts were established at Madras, Bombay, and Calcutta, and in certain books of instruction for the proceedings of the new court, it was for the first time laid down that under that charter all the common and statute law at that time extant in England was introduced into the Indian Presidencies, and all Parliamentary enactments passed since that period excluded unless expressly extended to India. By a charter of the 19th September, 1757 (31 Geo. II.), one moiety of the booty taken at the recapture of Calcutta under Colonel Clive and Admiral Watson was granted to the Company, and on the 14th January, 1758, his Majesty granted to them all booty taken by their ships and forces, and the disposal of any fortresses or territories acquired by them from any of the Indian princes and governors. This was the last charter granted directly by the Crown to the Company, all charters of subsequent date having been founded upon Acts of Parliament. In 1744, the Company obtained (17 Geo. II., c. 17) an addition of fourteen years, viz., to 1780, and in return they lent to the public £1,000,000 at 3 per cent. In 1781 a further agreement was made by which the trade was continued until 1794. By an Act of 1793, the trade was further continued until 1813, when the 53rd Geo. III., c. 155, was passed, opening the trade with India to the public, at the same time reserving exclusively to the Company the trade with China and in tea. This latter trade was to continue to the Company until the 22nd April, 1834, and by a statute of 28th August, 1833 (3 and 4 Will. IV., c. 93), the tea trade also was thrown open to the public, and the Company thereafter ceased to carry on any trade at all.

The earliest mention of tea in the old records is contained in a letter from Mr. Wickham, the Company's agent at Firando, in Japan, who, writing on the 27th June, 1615, to Mr. Eaton, at Miaco, asked for "a pot of the best sort of chaw." It is not certain when the first consignment of tea was sent home, but it appears that in 1664 the Company presented the King with a small quantity as a present; and three years later they directed their agent at Bantam to send "home 100 lbs. weight of the best tey that you can get." Writing in 1684 to Madras, the directors stated :—"In regard thea is grown to be a commoditie here, and we have occasion to make presents therein to our great friends at Court. we would have you send us yearly five or six cannisters of the very best and freshest thea." This was probably the commencement of the regular importation of that commodity into England.

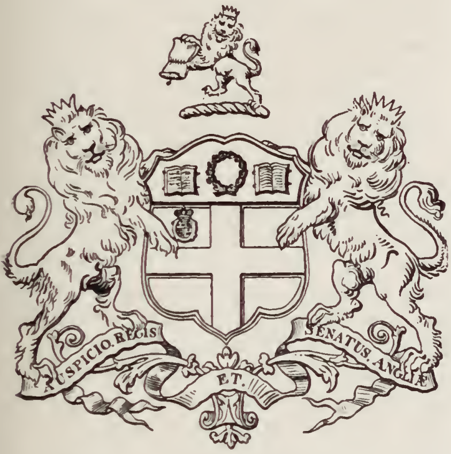
At the union of the two Companies the several minor factories were made subordinate to the three Presidencies of Bombay, Madras, and Bencoolen (Sumatra) respectively. By a Commission, dated 30th of December, 1709, Fort William, in Bengal, was also constituted a Presidency.

With the exception of the Company's commercial concerns, few matters of moment occurred until the year 1746, when hostilities commenced between the French and English forces. War between England and France was declared in March, 1744. Warlike stores were immediately despatched to Madras, together with as many recruits as could be procured; but notwithstanding the pressure put on the Government by the Court of Directors, they refused to send out any additional ships for the protection of their Indian possessions. The French acted otherwise, and sent out a fleet (in 1746), which captured Madras on the 21st of September of that year. An English fleet was only got in readiness in February, 1747, and the news of the loss of Madras arrived on the 24th of June following. The English reinforcements arrived too late to effect much good, but under the Treaty of Aix-la-Chapelle, Madras was restored to the English (21st of August). Before this an unsuccessful attack had been made on Pondicherri, in which Lieutenant Clive took part. The next great trouble was the loss of the Company's settlements in Bengal, and the inhuman sacrifice of life in the Black Hole at Calcutta (June, 1756). The recapture of Calcutta (on the 7th of January, 1757) by forces sent from Madras under Admiral Watson and Colonel Clive is sufficiently well known. In the meanwhile war had again broken out between England and France, which caused a renewal of hostilities in India; but on the capture of Lally (on the 15th January, 1761) by Colonel Coote, the French power in India was broken, and in 1769 the French East India Company ceased to exist. War with Hyder Ali and the Nizam soon followed, which lasted until 1769; and shortly afterwards occurred the Mahratta war, by which the Company obtained considerable accessions of territory. In 1780, they were again involved in war with Hyder Ali, who was aided by French troops. These engagements were concluded, to the advantage of the British arms, in 1784, and the same year Mr. Pitt's Bill for the future administration of the affairs of India was passed in Parliament. A few years after this, the Carnatic war against Tippoo Sultaun broke out, and peace was only concluded on the 19th March, 1792. In 1799, Tippoo, who had been engaged in secret negociations with the French, again forced hostile measures on the British, and a force under General (afterwards Lord) Harris, in which the late Duke of Wellington commenced his military career in India, was sent against him. In this war Seringapatam was taken, Tippoo Sultaun slain, and the empire of the house of Hyder subverted. The operations against Scindiah, including the battle of Assaye, occupied the British arms in 1802 and 1803; after this war was declared against Holkar, who was defeated, and a treaty was concluded with him in 1805. In 1810, the Isles of France and Bourbon were taken from the French, and in the following year Java was captured from the Dutch. Closely following upon these events came hostilities in Nepaul and with Cutch; war became necessary against the Pindarries, and against the Peishwa, whose territories were now annexed to the British possessions. In 1824, operations were undertaken against Burma, and in the following year Bhurtpore was attacked and taken. Thus, from 1746, to nearly the end of their commercial charter the Company was almost continually engaged in warlike operations, forming and consolidating an empire where it had previously possessed only commercial factories.

The records dating from the union of the two East India Companies are far more ample than those of an earlier date; but it is only from 1760 that the regular correspondence with Madras and Bombay begins. With a few scattered exceptions of earlier date, the consultations of the Bengal Government, however, date from 1703; of Madras from 1702; of Bombay from 1704; of Fort Marlborough from 1704; of Fort St. David from 1703; of Gombroon from 1708; of St. Helena from 1705, and of China from 1721.

In the early years of the 18th century all the proceedings of the several Governments were recorded in the public departments. The turbulent times that followed, however, necessitated the establishment of a separate military branch. Upon the acquisition of territorial possessions a revenue branch soon became necessary, whilst in connection with their dealings with the native kings and princes, foreign, secret, and political branches of the administration were also instituted. The establishment of mayors' courts in 1726 has already been referred to, and in 1773 an Act of Parliament was passed establishing a Supreme Court of Judicature at Fort William, of which Elijah Impey, Esq., was the first Chief Justice. With a view to improving the education of the Company's civil servants before going out to India, the East India College at Haileybury was established in 1805. No doubt, at times, some illiterate men had been sent out in the Company's service, for about 1670, one John Coltson, a member of Council at St. Helena was apparently unable to write, since he signed his mark (X) to the copies of consultations sent home. In 1809 a military establishment was formed at Addiscombe for the purpose of educating the cadets intended for the Company's engineer or artillery service in India.

Fig. 4.



Arms of Haileybury College.

Amongst the subjects of special interest during this second period into which I have divided the record series, may be noticed that in 1756 the Court of Directors sent out a Commission constituting Robert Drake, Esq., President and Governor, with a Council to manage all the Company's affairs at Fort William in Bengal, and all the several dependencies thereunto belonging, but, upon receipt of the news of the loss of Fort William and the rest of the Company's settlements in Bengal culminating in the "Black Hole" tragedy, and of their subsequent recapture, they suspended for the present the method of conducting the Company's affairs by a president and council, and appointed a committee in its place, but with similar powers, of whom Colonel Clive, Mr. Watts, and Mr. Manningham were to preside at their meetings for a month each in their turns. These, however, considered that the absence of a permanent president was "repugnant to the true interests of our Honourable Masters," and they accordingly prevailed upon Colonel Clive "to accept of being president of the Company's affairs in Bengal till a person is appointed from Europe." In January, 1760, Colonel Clive resigned his position in consequence of the receipt of a despatch from the Court, "almost every paragraph of which," he observed, "abounds with the most unbecoming language," the real reason being, it appears, the appointment of Lt.-Col. Eyre-Coote as Commander-in-Chief instead of himself. He was succeeded as President by Mr. John Zephaniah Holwell, one of the few persons who survived the "Black Hole" tragedy. Lord Clive returned again as President and Governor in May, 1765, which position he held until January, 1767. In 1771 Mr. Warren Hastings was appointed Governor, but shortly afterwards, under provision of Act 13, Geo. III., cap. 63, it was determined "That for the government of the Presidency of Fort William, in Bengal, there shall be appointed a Governor-General. . . . And it is hereby further enacted that Warren Hastings, Esq., shall be the first Governor-General." Warren Hastings was succeeded by Lord Cornwallis in 1786, whose rule was celebrated for two events, viz., the introduction of the permanent settlement in Bengal, and the second Mysore war. By Act 3 and 4, Will. IV., cap. 85 (1833), the whole civil and military government of the East India Company's territories and revenues in India was vested in a Governor-General and Councillors. Lord William Bentinck was the first Governor-General of India.

By the charter of King William III., granted in 1698, the Company were required to maintain ministers in India, and no such minister was to be sent out until approved of by the Archbishop of Canterbury, or the Bishop of London, for the time being. By letters patent issued on the 2nd May, 1814, the Bishopric of Calcutta was constituted (to be subject and subordinate to the Archbishop of Canterbury), and three Archdeaconries at Fort William, Fort St. George, and Bombay respectively. The Court also undertook to support the

Scotch Church in India. The first Bishop of Calcutta was the Rev. Dr. Middleton. He died in July, 1822, and was succeeded by the Rev. Dr. Heber. In consequence of the last-named measures, an Ecclesiastical Department was constituted in 1815. I must now briefly refer to the outlying factories.

The early attempts to establish factories in Borneo had not been very successful, and for some years they had been abandoned, but in 1731 renewed efforts were made to settle a factory at Banjarmasin, and in 1704 the King of that place granted permission for the erection of a fortification for the protection of the Company's establishment there; but the English were shortly afterwards forced to retire owing to an insurrection said to have been brought about at the instigation of the Chinese. Trade was not re-opened at Banjarmasin until 1738. In 1762, the Island of Balambangan was granted to the East India Company, and six years later a factory was ordered to be established there, the objects of which were stated to be (1) to divert the Chinese trade into this channel, (2) to draw the produce of adjoining countries thither, and (3) to form a port for the introduction of spices, and for the vent of Indian commodities. In 1771, it was ordered that the government of Balambangan should be vested in "a chief and two other persons of Council." Mr. John Herbert was the first chief. In 1774, an agreement was made with the King of Borneo, whereby the English engaged to defend that place against the Sulu pirates, and he, in return, undertook to give Balambangan an exclusive trade in the pepper of Borneo. In February, 1775, a band of Sulus captured the fort of Balambangan, and the Council with their establishment retired to Labuan. In 1803, Balambangan was re-occupied by the East India Company, but as they derived no benefit from the trade there, they withdrew in the following year, from which date no settlement was formed by them on the northern coast of Borneo, nor did they exercise any jurisdiction there.

At the union of the two Companies there existed five factories in Sumatra, and the principal one at Bencoolen, called Fort Marlborough, was made independent of Fort St. George, and formed into a Presidency. In consequence of the great expenditure on fortifications incurred there, the Court ordered that no more enclosures were to be formed, and that economies were to be otherwise introduced. This the Council yielded to under protest, but they declined to reduce the number of their soldiers, "not being willing," as they said, "to have our throats cut." In a treaty made with the Sultan in 1714, a promise was entered into by the latter and his rajas that each family, in their respective towns, should yearly plant 3,000 pepper trees, and the Company, in return for other privileges, undertook the guardianship of the country. In 1753, in order to increase the revenues, a duty of 5 per cent. was established on all imports at Fort Marlborough and its dependencies, except on piece goods and opium manufactured at Fort St. George, and on European commodities sent out by the Company. The Dutch now redoubled their efforts to harass the English and drive them out of the country, in which they were aided by the French, for in February, 1760, two large French ships of war attacked and took several of the smaller English factories on the island. Fort Marlborough was next captured, and the Council thereupon retired to Batavia. The British settlements in Sumatra were shortly afterwards re-established, and secured again to the East India Company by the Treaty of Paris of 1763. In 1785, Fort Marlborongh and its dependencies were placed in subordination to the Government of Bengal, and changed to a Residency under a Deputy-Governor. Sir Stamford Raffles was the last Lieutenant-Governor.

According to the stipulations of a treaty signed at London on 17th March, 1824, between the King of Great Britain and the King of the Netherlands, all the British possessions on the Island of Sumatra were exchanged for Malacca and its dependencies. The English establishments and stores were removed from Fort Marlborough to Prince of Wales Island and Singapore on the 5th July, 1825, whereupon the island was taken possession of by the Dutch, and thus ceased the British connection with Sumatra, which had lasted for upwards of two centuries.

The East India Company had given up their possessions in Java to the Dutch in 1683, and the latter practically assumed possession of the whole of the island. In 1758 the united Company re-established an agency at Batavia. In 1810 the president at Fort Marlborough informed the Court that the Dutch in Java had recently been much harassed by pirates, who had established themselves to the west of Bantam Bay, and he pointed out that the present appeared "the most favourable opportunity that could present itself for the accomplishment of any designs against the seat of the Dutch power in Asia," as the natives were disgusted with the latter, and would willingly side with the English in expelling them. At this time Holland had been annexed to France, and General Daendels was Governor of Java. He made preparations for defence against any attack upon the island by the British, and also for making further conquests, so that it was thought that the spice trade would probably soon have fallen had the French been permitted much longer to retain the absolute control of this island. Accordingly, a military expedition was sent to Java under the command of Lieut.-General Sir Samuel Auchmuty, which landed on the island on the 4th August, 1811. A decisive assault was made on the enemy's position on the 26th idem, when their army was completely dispersed, and the island conquered by the English. By a convention of the 13th August, 1814, between the British Government and that of the Netherlands, Java and its dependencies were restored to Holland.

As has already been stated, the first attempt to open trade with Japan was by Captain Saris, who reached Firando on the 12th June, 1613, where he was permitted to establish a factory, and shortly afterwards subordinate factories were formed at Nangasaki, Edo, Osaca, Shrongo, Miaco, and Tushma. In April, 1623, these factories were all abandoned, as they did not prove remunerative; and it was not until 1672 that attempts to re-open trade with Japan were made, but the emperor replied that inasmuch as our king was married with a daughter of Portugal, his enemies, he could not admit us to have any trade, and for no other reason. Other similar efforts proving unsuccessful, the Company abandoned their efforts to re-open factories in that country. In 1672, a factory was opened at Tonquin, which was, however, dissolved in 1697. As early as 1699 the English East Indian Company made an unsuccessful attempt to establish a factory in China, and after the union of the two Companies several similar fruitless efforts were made, but they were only enabled to carry on a trade at Canton through an individual termed the emperor's merchant, who paid a considerable sum for the exclusive privilege of trading with all Europeans. By 1715, however, the intercourse with Canton had assumed somewhat of a regular trade. The ships were despatched to China at stated seasons, and supra cargoes were appointed to each ship, who were to live, when at Canton, in one house, to keep but one table, and to meet at least twice a week to consult for the general benefit of the Company's affairs. The trade was constantly hampered by increasing impositions and embarrassments. In 1781, the Company made their first venture in sending opium to China, which subsequently increased to a large and profitable trade. In 1792, the Government sent Lord Macartney on an embassy to China, towards the expenses of which the Court of Directors contributed £30,000. The advantages to trade derived from this mission were, however, very small. In January, 1802, the Committee at Canton advised the Court that the American flag had been hoisted there for the first time, and in the following years trade was several times stopped at that port on one excuse or another. In 1816, Lord Amherst was sent as an ambassador to Pekin, whereupon the Emperor wrote to the Prince Regent, "Hereafter there is no occasion for you to send an ambassador so far, and be at the trouble of passing over mountains and crossing seas;" and in an edict issued at the same time it was stated, "I therefore sent down my pleasure to expel these ambassadors, and send them back to their own country, without punishing the high crime they had committed."

Apparently on the strength of the near conclusion of the East India Company's charter, on the 19th of January, 1831, an address was presented to the Viceroy by the Hong merchants in favour of the English trade being conducted, as then, by a powerful Company, as, if any change should be made, individuals would come of themselves, who would not be subject to one control, in which case responsibility would cease; whereupon the Viceroy issued an edict that "if the Company be dissolved it will, as heretofore, be incumbent to deliberate and appoint a chief who understands the business to come to Canton for the general management of the commercial dealings, by which means affairs may be prevented from going to confusion, and benefit remain to commerce." Shortly after this commotions occurred at Canton in consequence of the introduction of cotton yarn, which the natives complained had deprived of the means of existence, their women and children who had previously been employed in the spinning of thread.

On the expiration of the Company's charter in 1834 they determined to give up the China trade; but they continued to retain agents at Canton until February, 1840, when their agency there was withdrawn.

The Cape of Good Hope had been occupied by the Dutch since 1652, and they continued in possession until 1795, when it was captured from them by a fleet under the command of the Honourable Sir G. K. Elphinstone, with land forces under Sir Alured Clarke. In the following year an Order in Council was issued under which permission was given to all ships belonging to His Majesty's subjects, and ships and vessels belonging to subjects of any country or State at amity with His Majesty to trade with the Cape of Good Hope, with the proviso that the monopoly of the trade to and from countries to the eastward of the Cape was vested in the East India Company, and nothing was to be exported thence, except for sea stores only, or by the East India Company, or by their license. By the Treaty of Peace signed at Amiens in 1801, the Cape was ordered to be restored to the Dutch; but hostilities having recommenced in Europe, a force under the command of Admiral Baird retook the Cape on the 18th January, 1806. The colony has ever since remained in the possession of Great Britain, to whom it was finally ceded at the Congress of Vienna in 1815. The East India Company retained an agent here until 1835, and the India-office Records relating to that settlement extend to the 30th April of the following year.

St. Helena was granted to the East India Company by charter on the 3rd April, 1661. In 1665 it was taken by the Dutch, but they were expelled again the same year. The Company early encouraged settlers, and granted them lands. The great importance of this island to them was for provisioning their outward and homeward bound vessels. In January, 1673, it was again taken by the Dutch, and recaptured on the 14th May following, upon which the king re-granted it to the Company "in perpetuity." It appears upon the records that, on the 8th March, 1689, orders were sent to St. Helena to prohibit any of the Company's ships sailing thence "from putting into Ireland upon any occasion whatever, in regard that kingdom is at present in hostility against the English." The laws instituted on the island were very strict, especially with regard to slaves. In the event of a black striking or assaulting a white man, he was to undergo the punishment of mutilation; in the event of his resisting or opposing a white person, he was for the first offence to be branded on the forehead with the letter R, and for the second offence to be mutilated; for striking any white person with any weapon the punishment was death; for using saucy or impudent language he was to be whipped in the presence and to the satisfaction of the party offended. Several single women were sent out by the Company, who were to have their passage free, and diet at the Company's charge for a year, "unless they be in the meantime otherwise disposed of." In 1761, the vessels containing General Lally and other French prisoners stopped at St. Helena on their way home, and the Governor made advances of money to such of them as needed it. A bill given by General Lally for an advance of £100 is still in existence. In a letter of the 27th July, 1796, the Court of Directors gave instructions for the emancipation of their slaves on the island, thus anticipating by nearly eleven years the action of the Imperial Legislature in that direction. Perhaps the records of this island of the greatest general interest are those which relate to the custody of Napoleon Bonaparte there; these, however, are not voluminous, most correspondence on the subject having been sent direct to the Secretary of State, and not to the East India Company. In the consultations of the 14th May, 1821, occurs the following entry:—"Saturday, the 5th, died General Napoleon Buonaparte." He was buried on the 9th May. On the 5th January, 1829, Mr. Waghorn arrived at St. Helena, and a public meeting was held on the 8th idem, at which that gentleman explained his proposals for the establishment of steam communication between England and India, in connection with which he proposed that St. Helena should be a coaling station for vessels.

By the Act 3 and 4 Will. IV., the island of St. Helena was vested in the Crown from and after the 22nd April, 1834. Accordingly, Governor Dallas handed over the government to Major-General George Middlemore, C.B., on the 5th March, 1836, and thus ended the connection of the Company with the island of St. Helena, after an administration of it as Lords Proprietors for a period of 175 years.

We now come to the third and final section of the India-office records. The Company had passed through the stages of a purely trading enterprise and of half traders and half rulers, and it was now to relinquish its trading operations altogether, and assume, under the guidance and direction of Parliament, political and administrative functions and further wars and conquests, culminating in the consolidation of the Empire and ultimate extinction of the Company in favour of Imperial Government. The Act (3 and 4 Will. IV., c. 85, of 1833) under which this change took place, directed that the Presidency of Bengal should be divided, and that the entire government of the country should be vested in "The Governor-General of India in Council." Lord William Bentinck was the first Governor-General of India. The same Act also gave a right to any European to settle in India and buy or rent land. In 1838-39 commenced the first Afghan War, before the end of which Lord Auckland returned home, and was succeeded by the Earl of Ellenborough as Governor-General. This was shortly followed by the war in Sindh (1843), the result of which was the defeat of the Amirs by Sir Charles Napier and the annexation of their country, and in the same year Gwalior was subjugated.

In 1839, Aden was captured by a small force sent from Bombay for that purpose, and shortly afterwards, owing to the labours of Lieutenant Waghorn, a postal line to India was established through Egypt and the Red Sea. Sir Henry Hardinge, the new Governor-General, proceeded to India by that route. In December, 1845, broke out the first Sikh war, in which the Sikhs were driven back across the Sutlej by the British forces under Sir Hugh Gough, culminating in the battles of Aliwal and Sobraon, which left the English masters of the Punjab. Under Lord Hardinge the public service was opened, under certain restrictions, to native youths; he gave a wholesome stimulus to the subject of native education, a movement which shortly afterwards extended to the establishment of a university at Calcutta (1857). During his term of office every kind of private enterprise in India became widely developed, and a commencement was made of introducing railways in the country. In 1848, Lord Hardinge was succeeded by Lord Dalhousie. In the same year an outbreak occurred at Multan, which, though at the time put down, was but the prelude of the second Sikh war. In the following year the Punjab was annexed as British territory by a proclamation of the 30th March, 1849. Dalhousie ably followed his predecessor in the encouragement and development of industries and trade, and during his term of office railways were considerably developed; telegraphs were first introduced into India; measures were framed for lightening the burdens on Indian trade, and cheap postage was introduced throughout India; an Act was passed for establishing trial by jury throughout British India; and female education and the establishment of a school of art also marked this period of the administration of India. In July, 1854, a despatch from England gave a wide extension to education, and established a special department for that purpose. The systematic extension of irrigation in India also dates from this period, as well as the promotion of public works generally throughout the country. In 1852, the second Burmese war broke out, which resulted in Rangoon and a great part of the province of Pegu being added to the British possessions. Just before resigning office Lord Dalhousie annexed Oudh under orders from the Court of Directors, by Proclamation of the 13th February, 1856.

Up to 1854, the Governors-General of India had held also the separate office of Governor of Bengal; but in that year it was determined to constitute this a distinct appointment, and on the 1st May the Honourable F. J. Halliday took the prescribed oaths and assumed the office of Lieutenant-Governor of Bengal.

In February, 1856, Lord Canning took his seat as Governor-General, and was soon afterwards embarked in a war with Persia, and this was followed, in 1857, by the Sepoy mutiny, which at first shook the power, but ended in the consolidation of the British rule in India. In 1858, the government of India underwent another change, and by Act 21 and 22 Vict., c. 106, the East India Company ceased to exist, and the government of India was vested solely in the Crown. In accordance with the policy announced in Her Majesty's Proclamation of the 1st November following, which announced that the Queen had assumed the government of India, natives were to be assigned a larger share in the government of the country than they had hitherto enjoyed. On the 1st January, 1877, at a Durbar held at Delhi, the Queen was proclaimed Empress of India.

Since 1858, India has been comparatively free from internal troubles. In 1878-80 occurred the second Afghan war, and in 1885-86 came the third Burmese war, as a result of which the whole of Upper Burma was annexed.

With regard to the advances since made in the civil government of the country, it may be observed that native members are now appointed to all the Legislative Councils; revised land settlements have been made for long terms of years, on moderate and equitable principles, over nearly the whole of India outside the permanently settled districts. The topographical survey of India has now been nearly completed, and a geological survey has been carried over the greater part of the Empire. Forest conservancy, which was only systematically commenced in 1858, has now been extended to every district, to the great benefit of the country and of neighbouring populations. Since 1858 sanitation has made rapid strides, and education is extended over the length and breadth of the land, and at the same time trade and manufactures, finance, and the general condition of the people have everywhere improved. Famines, which during the past 100 years have repeatedly devastated various parts of India, have received the most careful consideration of the Government, and rules have been laid down with the view of meeting emergencies of this kind, whilst the development of irrigation, canals, and railways have done much towards mitigating the horrors that formerly attended these visitations. Since 1860 local self-government has been introduced, by which urban affairs are placed in the hands of local bodies, and the management of harbour affairs at the chief seaports has been committed to trusts constituted by law.

During the period embraced in this third section the records have greatly increased in bulk, and they may be said to be practically complete and continuous, whilst, owing to the development of the country, and the introduction of new branches of the Government, fresh series of records have from time to time been introduced.

With regard to Straits Settlements Records, I may observe that in 1772 the Government of Bengal were seeking to establish a commercial port in the Straits of Malacca, and obtained from the King of Quedah the island of Penang, which they subsequently named "Prince of Wales Island." In 1800 a district on the mainland opposite was also obtained and called Province Wellesley; and in 1805 Penang was constituted an independent Government, with Mr. Dundas as Governor. Malacca was taken from the Dutch in 1795, but restored to them by the Treaty of Vienna in 1818. The Dutch also held Rhio, and these possessions gave them the command of the Straits of Malacca and Sunda, and so in order to protect British trade and to secure one of the two passages to the Eastern Archipelago, Singapore was obtained by treaty from the Raja. For the first four years after its settlement, Singapore ranked as one of the dependencies of Fort Marlborough, and being maintained as a free port it grew and prospered. Malacca was restored to England in exchange for Java in 1824; and in 1826 Penang, Singapore, and Malacca were incorporated as one Government under the name of the Straits Settlements. These were transferred from the control of the Government of India to that of the Secretary of State for the Colonies on the 1st April, 1867, by an Order in Council issued under the authority of Act 29 and 30 Vict., c. 115. The separate records relating to these Settlements extend from 1769 to 1830, at which date they became a Residency subordinate to the government of India.

A brief allusion may, not inappropriately, be made to Ceylon before concluding, as that island was once governed by the East India Company. The first intercourse of the English with Ceylon took place in 1763, when an embassy was sent from Madras to the King of Kandy, without, however, leading to any result. On the rupture between Great Britain and Holland in 1795, a force was sent against the Dutch possessions in Ceylon, when the whole of their forts fell into the hands of the English. At first the island was placed under the care of the East India Company and made subordinate to the Government of Madras, but in 1802 the whole seaboard of Ceylon became, by the treaty of Amiens, a possession of the British Crown, and its connection with the East India Company ceased.

An account of the records of the India-office would not be complete without some allusion to the maps and charts. From the very commencement of the East India Company the logs of their sea-captains were made use of by Hakluyt in the construction of charts and maps. The commencement of the Indian Marine dates from 1613, when vessels were fitted out at Surat for the protection of commerce against the Portuguese and pirates, but it was not until the days of Rennell and Dalrymple that the great importance of marine surveying began to be appreciated. From 1770 some important surveys were commenced of the coasts of India, and in 1799-1800 the expedition to the coast of Egypt led to an examination of the Red Sea. At the beginning of the present century, a Marine Surveyor-General was appointed at Calcutta, but it was not until 1823, when this post was held by Daniel Ross, that a really scientific method was introduced. In 1832, the Bombay Marine was converted into the Indian Navy, and an admirable system of surveying was inaugurated under the auspices of its first Commander-in-Chief, Sir Charles Malcolm. In 1862, the Indian Navy ceased to exist, and it is believed that the official records of it, and of the Bombay Marine, have been almost entirely destroyed. The charts, with the copper-plates, original drawings, and sailing directions were transferred to the Admiralty in 1861. In 1873, a Marine Survey Department was established, by which systematic surveys of the coast of India were to be carried on, and copies of all original surveys were to be forwarded to the Admiralty Hydrographer for publication.

The first land surveys of India were no doubt made in connection with military operations, and the land survey and mapping of British India advanced with the acquisitions of territory. Major Rennell was the first to give practical shape to these surveys, and has rightly been called the father of Indian geography. It was not, however, till the end of the last century that a trigonometrical survey was generally allowed to be the only accurate basis for the mapping of a country, and this work was commenced by Major Lambton, whose labours are recorded in manuscript volumes deposited in the geographical branch of the India-office Record Department. In 1823 a commencement was made with revenue and topographical surveys.

The publication of the great trigonometrical and topographical surveys was executed in this country by Mr. John Walker, to whom also was entrusted, in 1836, the custody of all the geographical records. In 1869 it was determined that, for the future, the engraving and publication of maps should be undertaken by the Surveyor-General of India, and a Geographical Department of the India-office was also formed for the purpose of receiving, analysing, and arranging for general reference and use, all geographical and geological documents, for the distribution of maps in this country, and for transacting all business connected with the surveys and other scientific branches of the service. The maps and records handed over to the Geographical Department were found to be in a state of indescribable confusion, and undergoing rapid deterioration, whilst many maps and memoirs had entirely disappeared, which can never be replaced. Steps were immediately taken for repairing, classifying, and arranging what remained, and a most valuable collection of manuscript maps and other documents is now open for reference and inspection.

Thus have I attempted to give a brief sketch of the India-office Records; complete it cannot be called, but, like a scaffolding, it affords some indication of the form and size of the building behind, though but little of its interior arrangements. Within this scaffolding I hope to commence the erection of a monument worthy of the memory of those bold adventurers who laid the foundation of British Empire in the East, and of those noble and able administrators who have upheld and maintained the honour and dignity of the Queen Empress in India. It is not in the order of events that this monument should ever be completed, but the scaffolding will, I trust, remain, and prove of service to those master builders to whom the working tools shall be entrusted, after those who are now employed upon the work shall have laid them down.

Principal Acquisitions of Territory in India.

1639.—Madraspatam.
1669.—Bombay.
1690.—Fort St. David.
1694.—Anjengo.
1698.—Calcutta.
1708.—Tellicherry and Ennor.
1734.—Dharmapatam Island.
1742.—Villages in Chingleput.
1749.—St. Thomé, Devikota and villages.
1750.—Punnamali District.
1756.—Villages in Kolaba and Ratnagiri Collectorates.
1757.—24 Parganahs.
1758.—Vizagapatam.
1759.—Nizampatam, Masulipatam, and towns in Godavari and Kishna Districts.
1760.—Burdwan, Midnapore, Chittagong and Hill tracts of Chittagong.
1765.—Bengal, Behar, Orissa, and Garo Hills.
1768.—Circars in Ganjam, Vizagapatam, Godavari and Kistna Districts.
1772.—Chunar and Allahabad Forts.
1775.—Benares, Jaunpore, Mirzapore, and Islands of Salsette and Karanjah.
1778.—Nagore.
1781.—Sadras, Bimlapatam, Palicole, Porto Novo Factory, Tuticorin, Negapatam.
1783.—Porto Novo, Cuddalore.
1792.—Calicut and parts of Malabar, Madura, Salem and North Arcot Districts.
1799.—North Canara, South Canara, Coimbatore, Nilgiri Hills, Tanjore, and parts of Salem and North Arcot.
1800.—The Ceded Districts (Madras Presidency), City Fort of Surat, &c.
1801.—Etah, Etawah, Mainpuri, Fatehpore, Cawnpore, Allahabad, and other Districts of the North-West Provinces, Armagon, the Chingleput District, and Carnatic Payen Ghat.
1802.—Other parts of Districts, North-West

Provinces, and Parganas in Ahmedabad, Kaira, Broach, and Surat Collectorates.
1803.—Upper Doab, Banda, Hamirpur, Cuttack, Balasore, Broach, Hurriana, &c.
1805.—Kaira and Karnal.
1810.—Fatehabad.
1812.—Ratnagiri Collectorate.
1814.—Cochin.
1815.—Parts of Simla District, Kumaon, Dehra Dun, &c.
1817.—Saugor Districts, and parts of Ahmedabad, Kaira, Broach, Surat, and Thana Collectorates.
1818.—Districts in Central Provinces, Ajmir, and parts of Poona, Ahmednagar, Sholapur, Sattara, Nasik, Khandesh, Kolaba, Ratnagiri, Dharwar, Belgaum, and Khaladghi Collectorates.
1818.—Sirsa.
1822.—Parts of Ahmednagar and Sholapur Collectorates.
1824.—Pulicat, Chinsurah, Dacca, Patna.
1825.—Assam, Naga hills.
1826.—Parts of Arakan and Tenasserim Divisions.
1829.—Parts of Jaintia and Khasi hills District.
1830.—Cachar, Simla.
1834.—Coorg.
1835.—Jaintia, Darjeeling, Ferozepore, parts of Muzaffanagar, Mirat, Bulundshahr, Alighar, Katkhai, and Katgurh.
1839.—The Mandai State.
1840.—Jalaun District and Banki.
1841.—Assam Duars.
1843.—Sind.
1844.—Kolaba State.
1845,—Tranquebar.
1846.—Lahore and other parts of the Punjab.
1847.—Parts of the Punjab.
1848.—Parts of Sholapur, Satara, Dharwar, Belgaum, and Kaladgi Collectorates.
1849.—Parts of the Punjab.
1850.—Sambalpur, Sikhim, Sanawar.
1852.—Oodeyput.
1854.—Jhansi, Nagpur, Sanawar.
1856.—Oudh, Tanjore Fort.
1857.—Jhajjar Territory.
1858.—Banpur and Shahgarh.
1860.—Upper Godavari Districts, Nimar, Harda, and Hindia.
1861.—Panch Mahals, Shillong.
1865.—Eastern Duars, Dewangiri and Bengal Duars.
1878.—The Peint State.
1886.—Upper Burma.

DISCUSSION.

Sir WILLIAM W. HUNTER said this most interesting and erudite paper was peculiarly opportune at the present time, when Indian affairs were becoming more and more frequently the subject of discussion in Parliament and in the Press. Under these circumstances, the Indian records must become more and more a national concern, and he was glad to hear that so much had been done recently in the India-office towards the preservation of these valuable heirlooms. His own experience with regard to Indian records extended over twenty years, and he was sure that anyone who remembered how little attention they used to receive twenty years ago, would rejoice at what Mr. Danvers had told the meeting regarding the efforts now being made for their classification and arrangement. It was not until four years after the downfall of the Company that Sir Charles Aitcheson's magnificent collection of Treaties and Engagements placed the honourable facts of the Company's dealings with the native princes before the English nation, and thirteen years elapsed after the downfall of the Company before the first general census of India was attempted. Nor was it until a later date that any systematic attempt was made to place before the public the facts connected with the administration and resources of each British district in India. He perfectly agreed with Mr. Danvers in the charge which he brought against Indian historians to the effect that they went on repeating what their predecessors had said without correction or verification from the manuscript records. The only attempt at a scholarly history of early British India was James Mill's, of which the first edition was published in three volumes in 1817. Mill went to the India-office records and worked from them, and until Indian historians of our day will take the same trouble to go to the original sources, Mill will never be superseded. It was a great misfortune that Mill's history should not be superseded, because, though Mill wrote with a command of exact language and with great knowledge of facts, he also wrote as a philosopher who started with preconceived ideas, and who only found in the facts of Indian history a confirmation of his preconceptions. That book had, nevertheless, dominated the public conception regarding the government of India. In reading the discussions in 1858, he found it quoted in Parliament, in the Blue-books, and in the press. But its influence was not confined to England. For example, in the great rent suit in Calcutta in 1865, which readjusted the general rent system of Bengal, he found that while some of the learned judges of the High Court went back to the original records or to Harrington's Analysis, the majority contented themselves with what Mr. Mill had printed in 1817. During the last 12 or 13 years the whole system of land tenures in Bengal had had again to be readjusted. A Commission was issued, and after a long inquiry the case was placed before the Legislature. He well remembered how in the Select Committee, as each clause of the Bill was torn to pieces, when either side wanted to quote something against the other, and were at a loss for an authority, they fell back on Mill. But he must say one word in defence of the historians. It had been his duty to attempt to write a general history of India, and when he began his task about twenty years ago, he found there were no local materials to refer to. He went to the District Record Rooms in Bengal, and made a collection of materials. But to go through fifty record rooms in a single province would have taken half a lifetime, and to do the same throughout all India would have required three or four lifetimes. Accordingly he tried the more central Record-office in Calcutta, the Board of Revenue, and there he made a precis of upwards of 14,000 letters which the Government had very generously printed. But the tradition of secrecy was still so powerful that they were not published to this day. He also went to the Board of Revenue in the North-West Provinces, and made a precis of their records. He should add that both Sir Alfred Lyall, when Lieut.-Governor, and Sir John Strachey, had endeavoured to render the most important of those records available to the public. In Bombay, too, efforts had been made to publish the records, and the valuable minutes and despatches of the Hon. Mounstuart Elphinstone, which contained some of the finest prose writing in the English language, and which formed a reservoir of political knowledge and wisdom, had been edited. But while something was being done in India, more required to be done in England, not only with regard to continuous effort in rendering the records of British India available to the British nation, but also in seeing that after the records were printed they should reach the people who knew how to use them. He had more than once received from enthusiastic compilers the initial proof-sheets of a series of records which were about to be printed, but of which he never heard anything more. Either they did not go on with the work, or when the records were printed there was no mechanism for their circulation. He ventured to hope that Lord Harris, when he took up his great office in India, would spare a few minutes from the weightier concerns which would fall upon him, to give his influence in favour of the continued publication of the Bombay Records. He (Sir William) fully realised that the publication of records was an expensive undertaking, and the task of rendering them available to the public (even after they had been edited and printed) was a somewhat complicated one. But he felt sure that the proceedings of that evening, and the vote of thanks which would be unanimously given to Mr. Danvers, might be taken as a proof of the cordial sympathy of the Society of Arts with the efforts of the Secretary of State, and those under his authority, to make the Indian records really available as the materials for Indian History.

Sir Owen Tudor Burne seconded the resolution, which was carried unanimously.

Mr. Seton-Karr said that when Lord Harris arrived in Bombay he would find that some records had already been inspected and published by Mr. Forrest, and there was no more competent person to do what Sir William Hunter said ought to be done in making them available for public information. He would also add that if there was any person competent to give a complete history of India, it was Sir William Hunter.

The Chairman said he sincerely joined in the vote of thanks which had been passed to Mr. Danvers for his exceedingly interesting paper, which, from the public point of view, was exceedingly valuable. If he might offer any opinion upon the paper and the remarks which had followed, he would say that he thought the East India Company had been a little hardly treated. After all, it must be judged by the circumstances which affected it, not by those which prevailed at the present day. The company was in the position that many present were, and which thousands were in the city of London—they were merchant adventurers, and he did not know that it was the custom nowadays for merchant adventurers to be very anxious to make public all their private affairs. He was therefore anxious to gloss over as much as possible the little weaknesses of the East India Company in not keeping public records, or occasionally in surreptitiously destroying a few that might be awkward in certain circles, when they knew there was considerable competition against them, and competition not only by other merchant adventurers, but by Government itself. He preferred, therefore to think of the great debt of gratitude which the nation owed to those few men who had the pluck so long ago, to start with great success what had proved to be the most magnificent undertaking the world had ever seen. Mr. Danvers, who no doubt had the very best information on the subject, said that in this state of advanced civilisation we were so economical that we were actually using worse material for the purpose of keeping our records perfect than the old East India Company; indeed, far worse than the Pagans and heathens of some 2,000 years ago, whose records remained as perfect probably as when they were put up. He thought we ought to be very grateful to the East India Company for the honour it had brought on England. Mr. Danvers, in the preparation of this paper, had done him the honour of displaying upon the screen the portrait of his ancestor, though there were many far more distinguished men whose likenesses might have been presented.

FOREIGN & COLONIAL SECTION.

Tuesday, January 21st, 1890; Sir Philip Cunliffe-Owen, K.C.B., in the chair.

The Chairman, in introducing Mr. Sha

referred to him as a colleague in the work of the Indian and Colonial Exhibition, where he did so much for the introduction of Ceylon tea. The planters of Ceylon were exceedingly fortunate in having their interests represented by so energetic, persistent, and able an advocate. He (the Chairman) was able to do something for Indian tea at the Paris Exhibition, and in 1878, the Grand Gold Medal of Honour was awarded by an international jury to the Viceroy of India for the tea then exhibited from India. He was quite sure that if Ceylon were now to go in for any great international competition she would win first-class honours for her tea.

The paper read was—

THE TEA, COFFEE, AND COCOA INDUSTRIES OF CEYLON,

By John Loudoun Shand.

Ever since Bishop Heber, with missionary zeal and poetic license, drew his well known word-picture of Ceylon; ever since Emerson Tennent gave the world his classic and unrivalled "Ceylon;" still more, since Ceylon became a favoured outlet for the employment and investment of the youth and capital of the mother country, and a great producing source of common articles of daily food, attention has been much directed towards it, and the name has become familiar to English ears; but changing circumstances, and the rapid march of time, soon make obsolete the history of commercial enterprises which have tropical agriculture for their parent; and my desire is to convey to this Society for the Encouragement of Arts, Manufactures, and Commerce information, as accurate and as condensed as possible, upon industries the promotion of which is mutually important and mutually advantageous to producer and consumer, to mother country and colony.

A sketch of the position and prospect of these industries which have effected so vast and so beneficial a change on the scene of production would be necessarily incomplete without a brief description of Ceylon, and a brief reference to the condition of the island prior to these developments.

Ceylon is situated at the extreme south-east of the Indian empire; it contains about 25,000 square miles, and has a population of about 3,000,000; the land all round the sea-board is flat, but in the centre of the island there are mountain ranges rising to a height of 8,300 feet above sea level, and it is chiefly upon the slopes of these hills that the cultivation of tea, coffee, and cocoa is carried out.

The climate is very variable, more so in extremes of dryness and moisture than of temperature, the rainfall varying from 35 inches annually in some parts of the low country, to 230 inches on the western slopes of the hills exposed to the full force of both north-east and south-west monsoons; but as an abundant and well-distributed rainfall is essential to the successful cultivation of the products I am describing, these industries are generally carried out under healthful climatic conditions.

Just as the Ceylon of to-day is the great centre of eastern transhipment, the converging point for steamers from Europe, India, China, and Australasia, so from its geographical position, very early in the commercial history of our world, it became the emporium at which the merchants of China used to meet the Arab traders from the Red Sea and Persian Gulf, and the natural wealth of Ceylon, its ivory and peacocks, its pearls and precious stones in great variety, its cinnamon and rare woods, made it a great point of primitive commercial attraction.

In 1505, the Portuguese, who were then the great navigators of the world, seized possession of the maritime provinces of Ceylon, attracted towards it partly by its geographical position near India, which they already looked to with longing eyes, and partly by the doubtless fabulous rumours of its immense wealth. The Portuguese occupation extended over a century and a half; but beyond the Roman Catholic religion, which they established and somewhat forcibly inculcated, a few descendants of mixed race, who still cling to a Portuguese patois, and honorific names and titles, which the natives eagerly embraced and jealously maintain, but little remains to mark Portuguese supremacy.

In 1656, the Dutch ousted the Portuguese, and held possession of maritime Ceylon for 140 years. Churches, schools, seats of justice, canals, roads, the systematic extension of the great cinnamon and coconut industries, and the introduction and successful cultivation of many economic plants, mark an era of activity and advancement, but material progress was confined to the maritime provinces, for, sullen and secure behind their mountain fastnesses, the Kandyan Highlanders, though willing to trade and barter, resented intrusion. In 1796, the British dispossessed the Dutch, and the treaty of peace of Amiens ceded to the Dutch the richer and far larger island of Java, and the more importantly situated Ceylon remained British.

After several years of constant embroilment and harassing petty warfare, the Kandyan king, was, in 1815, deposed and banished to India, and British rule was established all over Ceylon, the Kandyans themselves, though they had declined to yield to the slave-driving Portuguese or the trade-monopolising Dutch, being not averse to accept a government which offered them a far greater measure of freedom and justice than they had enjoyed under the tyrant who had been dethroned, and from this date, with the exception of one or two instances in which excess of zeal or indiscretion on the one part, and individual desire to gain or regain power on the other, led to petty rebellion, the cordial relations between British and Kandyans have become steadily more and more closely knit, and prosperity has almost continuously advanced.

Coffee (*Coffea Arabica*) was introduced into Ceylon by the Arabs, who, doubtless, allured by the contrast between the evergreen and beautiful island and their own sterile homes, occasionally prolonged their periodical visits, and have left unmistakable evidence of their incursions in a progeny of mixed descent.

Flowers form a favourite votive offering at the Buddhist shrines, and centuries before the Christian era, this religion was firmly established in Ceylon, and coffee seems to have been at first planted in the vicinity of temples rather for its beautiful and fragrant jasmine blossom than for its more practical purpose; in time, however, the Singalese appreciated the excellence of the bean, and became, as all who have access to pure coffee do, a nation of coffee-drinkers, and a small commerce was carried on in coffee with the Dutch, the exports, however, never exceeding 3,000 cwt. Several years after the political settlement, attention was drawn towards the Kandyan hills, as a possible field for the even then surplus British capital and industry, and the success which had attended the crude cultivation of the Kandyans, coupled with the imminent manumission of slaves in the coffee-producing West Indian islands, pointed at coffee as a possible source through which the latent wealth of Ceylon might be profitably developed. Sir Edward Barnes, the Governor of Ceylon, himself formed one of the first plantations, and before long clearings for coffee were made on several different ranges of hills.

The enterprise was of course subject to all the vicissitudes inseparable from an investment of which knowledge could alone be gained by experience. Failures and successes alternated, and on more than one occasion the withdrawal of credit, and the depreciation in value of coffee, caused stagnation and threatened collapse. But, in spite of all difficulties, coffee in time became not only the staple export from Ceylon but the pivot upon which nearly all other exports and imports depended, and the means whereby the island was raised from the mere negative position of a naval and military station, and attained a height of progressive civilisation unsurpassed in her Majesty's dominions.

There are, of course, many operations necessary before forest land can be turned into a coffee plantation. After the selection and survey of the land, the trees on the area intended to be planted are felled, and when sufficiently dry are burnt off. The land thus covered with charred logs and sticks is roaded and drained, and evenly laid out for the digging of pits for the reception of the young plants. These pits, which are dug in even lines generally five or six feet apart, and to a depth, according to circumstances, of from fifteen to twenty-four inches, are carefully filled in with the ash and decaying vegetation of which the surface soil is composed. The coffee plants, meanwhile, having been raised in nurseries, are planted out in the pits as soon as the rainfall is sufficiently abundant. The young trees have many enemies—rats, crickets, and insects of many kinds; but new plants are constantly supplied where vacancies occur, and soon the trees require to be topped, to reduce them in height for convenience of cultivation, and to encourage them in throwing out lateral branches. Generally in the second year after planting the young trees begin to blossom, and seven months afterwards yield their first fruits; and as they increase in age and strength, until they reach maturity, so should they increase also in yield.

The operations connected with the harvesting and preparation of coffee are very simple, the bright red cherries, generally containing two beans each, are brought into the pulping-house, and from there passed through cylinders or discs, commonly called pulpers, by which operation the skin, which is used for manure, is separated from the beans, which fall into a cistern, where they are left to ferment until the mucilage with which they are covered can be freely washed off, the beans are then dried sufficiently to admit of their safe transport to

Colombo, where, after further drying, the outer husk, called the parchment, is peeled off. They are then sized and packed in casks, and are ready for the roaster.

It is painful, however, to record that the coffee industry of Ceylon, which converted nearly 300,000 acres of trackless forest into busy scenes of active life, which found an outlet for many of the younger sons of England, who, after passing through the various ranks and gaining the necessary knowledge, generally acquired plantations of their own, and returned to spend the fruits of their industry in their native land; which gave employment to 300,000 agricultural labourers of British subjects of Southern India, and to more than that number of the natives of Ceylon, who as mechanics, carriers, purveyors, and in numerous other capacities, depended upon coffee; which covered the island with a network of roads, and caused the hills to echo with the shrill whistle of the locomotive, where, a few short years before, the elephant's trumpet and the sambur's bark were the solitary sounds; which provided the revenue by which Government, with the improved light of science, has restored many of the ancient irrigation works, magnificent in conception, often faulty in construction or design, and thus provided for many who literally cast their bread upon the waters—the blessing of abundance; which placed education and Christianity within the reach of all, has dwindled to but a shadow of its former self, and had other enterprises not arisen, which promise to be yet more extensive and yet more permanent, the history would, indeed, be a sad one.

From 1867 to 1870, the exports of coffee were highest, and large tracts of land were rapidly being brought under cultivation. In 1868, however, in one of the youngest and most promising districts, a fungus (*Hemileia vastatrix*) attacked the leaves of the coffee tree, and soon spread over all the coffee-producing districts.

It was thought lightly of at first, and sudden as its appearance so was its disappearance looked for, but a fungus in a climate of equable temperature, where there is practically no check of season to retard development, and where a large area of land is planted exclusively with the one thing it feeds on, is a terribly dangerous enemy. The energy of the tree, which should have gone to the production of fruit, was diverted to the incessant reproduction of leaf. All remedies which science, aided by liberal cultivation, could suggest were tried. Fresh seed was introduced from various coffee-producing countries, and a variety of coffee called "Liberian," a larger and apparently more robust tree, was imported from the West Coast of Africa and largely planted, but it was powerless to resist the fungus; and despite a large increase of coffee-bearing land, the exports began to dwindle.

In 1873, a great stimulus was given to the cultivation of coffee by a remarkable rise in prices in European markets. There was at the time a considerable influx of capital. Credit was abundant. Coffee property and forest land went up to fabulous prices, and it is easy to see now, with the lurid light of baffled hope, how economic conditions were often set at defiance, and the island was brought to the verge of a general financial crisis.

EXPORTS OF COFFEE.

		cwt.
Average for five years	1851-55	387,240
,,	1856-60	552,219
,,	1861-65	721,405
,,	1866-70	956,153
,,	1871-75	851,895
,,	1876-80	744,209
,,	1881-85	380,145
Average for four years	1886-89	155,122

NEW PRODUCTS.

It was fortunate for the future of Ceylon that experiments had been going on in the introduction of new products, and Dr. Thwaites, the late Director of the Royal Botanic Gardens at Peredenya, near Kandy, who, from the first, took a very grave view of coffee-leaf disease, had done much to instil into planters the desire to try new things, and fibres and foods, dyes and drugs, gums, spices, tobacco, were all extensively tried with varying success. A word or two must be said about the cultivation of cinchona, the quinine-yielding tree, because the export table tells such a remarkable tale of rapid development, and Ceylon, which in 1876 shipped 16,842 lbs. of bark, and in 1886 15,000,000 lbs., an increase of nearly a thousandfold, it has been the great agency through which this valuable medicine has been placed within the reach of all.

Cardamoms also (*Elettaria Cardamomum*) deserve mention. In 1876 4,965 lbs. were exported; and in 1887, 321,560 lbs.

Cinchona trees could be freely interspersed between the rows of coffee, and both these articles of commerce and some others formed valuable adjuncts by which many planters were able to tide over the period between the cessation of coffee crops and the commencement of tea harvest; for it was to tea, which had now shown its thorough adaptation to the circumstances of Ceylon, that all looked for a restoration of prosperity.

Tea (*Thea camellia*) was introduced into Ceylon by the Dutch, but does not seem to have been cultivated for commercial purposes. In 1842, an experiment was made on a considerable scale, but though the growth of the tea trees was favourable, the mystery then supposed to attach to the manufacture of the leaf prevented cultivation of the plant being extended; and it was not again until 1866, after tea had been very successfully established in India, that it seems to have again attracted attention in Ceylon. The seed from the trees which had long been growing uncared for in the Botanic Gardens was planted out, and a Commissioner was, at the request of the Planters' Association of Ceylon, sent by the Ceylon Government to India, to report upon the tea enterprise. The result of the report was so far satisfactory that one or two fields of tea were planted on systematic principles as soon as seed was procurable. Coffee was, however, still doing so well that it almost monopolised European energy, and it was not until the ravages of the coffee fungus made it plain that ruin could only be averted by the substitution of other products, that the cultivation of tea was entered upon extensively, and though directly the result of the failure of coffee, Ceylon started tea with certain advantages.

The fact that excellent tea could be manufactured, and an abundant yield secured under suitable conditions, had been already established, for the early formed gardens had been supplying local demands, and had probed the London market with success. From these gardens a good deal of the seed for the formation of nurseries was procurable, and the experience which the pioneers had gained was freely placed at the disposal of others. Ceylon had also the great advantage of being able to avail itself of the advice and assistance of Indian planters, and to profit by the experience which, in the face of difficulty and obstruction—which in great measure paved the way for Ceylon—had built up the great Indian tea enterprise.

There was a further advantage which, though often painfully felt, has given an element of safety to the capital invested in tea in Ceylon. The general distrust naturally arising from the failure of coffee caused a great withdrawal of credit and purchasing power, and borrowing facilities were at so low an ebb that, though success was apparent, it had often to be attendant upon means, and the enterprise has been built up on a sound financial basis, entirely free from any rush of speculation; but still the progress has been marvellous, and perhaps unprecedented in commercial history. In the Ceylon Customs, during the year ending 30th of September, 1880, 114,845 lbs. of tea were exported; 1885, 4,352,895 lbs.; 1889, 32,516,682 lbs.; and during the current year more than 40,000,000 lbs. will probably be exported; and as tea has thoroughly adapted itself to the conditions of Ceylon, which possesses the great advantage of a good climate, a cheap and abundant labour supply, and unrivalled facilities for the transport of produce from plantation to market, and as there is still much suitable land available, it is impossible to assign the limits of the enterprise.

The various operations connected with the formation of a tea plantation are very similar to those required for coffee cultivation. The young plants are removed from nurseries and placed in pits, at distances from one another varying according to circumstances, but an acre of tea land generally contains about twice as many plants as an acre of coffee.

A year or so after the planting out of the young trees, which grow very rapidly, they are cut down to a height of about three feet, and encouraged, for convenience of cultivation, to assume the form of a bush rather than of a tree; and as soon as the tree is old enough the work of plucking commences. Tea is made from the very tender leaves and buds, great care being required not to impair future plucking. The tea harvest in Ceylon is perennial, except when the trees are taking the rest which is annually imposed upon them by pruning. The whole area of the plantation requires to be plucked over, according to climatic circumstances, from seven to 12 days. The green leaf is then carried to the factory, and weighed and spread out on trays to wither, four pounds of green leaf generally giving a return of about a pound of manufactured tea. After sufficient moisture has been evaporated, and the leaves have become flaccid, they are placed in heavy rollers, and all the cellular tissues are thoroughly broken up They then go through a slight process of fermentation, during which the colour changes from green to a bright copper. They are then passed through furnaces and thoroughly baked, and here the actual manufacture ends, and all that has now to be done is to sort into the various grades of orange pekoe, pekoe, pekoe souchong, &c., &c., and to pack in lead-lined chests, when the tea is ready for its destination, each of these operations is carried out as far as possible with the assistance of machinery, and requires scrupulous cleanliness and unremitting attention; and it is perhaps owing as much to careful preparation as to natural advantages that, since Ceylon tea became established in London as a commercial article, it has averaged higher prices than the tea from any other country.

What coffee planting did for Ceylon has been already told, and its great successor—though the immediate profits derived from tea cultivation may not always be so great as from coffee—has placed the island on a firmer and more permanent basis.

The cultivation of coffee was confined to a hill zone, the limit of which varied with soil and climate; but both above and below that zone coffee refused to yield crops, and it was also specially sensitive to ill-treatment, and at once resented neglect. The area available for coffee was therefore limited, and as nearly all suitable land had been planted, and when trees got old and exhausted the same land could not be replanted, though the end of coffee has been precipitated by leaf disease and accompanying pests, it was in the course of nature bound to come; and the question so frequently asked—whether Ceylon is likely to become a large coffee producer again can, so far as the present generation is concerned, be answered in the negative.

Tea, on the other hand, grows with the greatest freedom. If left neglected, it triumphs over weeds, and asserts itself in the midst of a dense jungle undergrowth. It flourishes equally from sea level to the tops of the higher mountain ranges, so much so that it is still an open question whether a tea estate in the low country, with its large yield of strong but somewhat flavourless tea, or one at a higher elevation, where reduced yield is compensated for by increased flavour, is the better investment.

There are few, if any, economic plants which thrive over so large a portion of the globe as tea, and though an expansive market to grow for, its very hardiness would give rise to the danger of over-production were it not that the cultivation, plucking, and manufacture of tea require so much human labour that it can only be grown with profit where population is dense, and requirements of life are cheap, and in this respect Ceylon posseses unequalled advantages. The native population would be sufficient for all wants, but it will generally only labour intermittently, as the Singalese have their own fields to cultivate, and the religion of Buddha requires the observance of many festivals; and as a resident labour force which will labour uninterruptedly is indispensable for the successful cultivation of both tea and coffee, the labour force is recruited from the densely populated villages on the Malabar Coast, where life is hard and food ofttimes scarce; and when the coolies have crossed the narrow strip of blue, which separates Ceylon from the mainland, and which is as precious to it as the English Channel to this island, they readily accept the bettered condition of life, and though under no indenture, and free to come or go at will, many settle down on the plantation where they are comfortably housed with their wives and children, and never return to their native land. A full grown man's wages are something under sixpence a day, and for two-thirds of this sum he can purchase as much rice, curry-stuff, betel, tobacco, and salt fish as he can consume, and neither custom nor climate requiring a lavish expenditure on clothing, though the love of dress is strong, his means are ample for his humble wants, and many of these labourers remit money to their relatives in India. Each coolie is allowed a piece of ground on which he cultivates vegetables, many of them keep poultry and sheep, and some rise to the dignity of possessing a cow.

The absolute dependence of the planter upon his coolies for success, the ready way in which they respond to generous treatment, and their really improved condition of life, promote a thorough understanding between master and servant; they benefit and suffer together, and during the severe strain of bad times which followed the failure of coffee, conscious of their employers' difficulties, coolies not infrequently volunteered to accept reduced wages.

In Ceylon, apart from many of other items of expenditure, it requires about two-thirds of a day's labour to produce a pound of tea; thus, if the average rate of labour is sixpence, fourpence is expended upon the manual labour necessary to bring a pound of tea to market. In countries where the day's wage is a shilling, eightpence would have to be expended on manual labour;

and though there are several parts of the British empire where tea may be grown profitably for local consumption, cheap labour is indispensable to compete successfully in European markets.

Cocoa (*Theobroma cacao*) was introduced into Ceylon by the Dutch; and though plants were occasionally distributed from the Peredenya Gardens to different parts of the island, and the desirableness of cultivating it for commercial purposes was constantly im. pressed upon planters by the directors of the gardens, it was not until 1873 that an experimental shipment was sent to London from the Pallekells estate, where a few trees had been planted for ornamental purposes. The report on this shipment was so satisfactory that a considerable area on the estate was soon planted, and the decadence of coffee induced others with suitable land to follow the example, most of the plants being supplied from nurseries raised on the estate mentioned, though several varieties of the plant were also introduced. Though the enterprise has assumed considerable dimensions, it has been somewhat of a disappointment. The quality of the beans is excellent, but the plant is very subject to insect pests, and the cultivation requires a well-distributed rainfall, rich soil, and shelter from wind—conditions not often found associated in Ceylon. As the trees get older, and draw nourishment from deeper sources, there is reason to expect they will be less subject to pests, and less dependent upon weather, but there is no immediate prospect of the export being large, though it might certainly be trebled if the natives, among whom many plants have been distributed, took to cultivating it. Most of the best cocoa land in Ceylon is in the hands of natives in sheltered pockets of rich soil, as the Kandyan valleys; and though in time they will probably awake to the advantage of cocoa cultivation, they are generally slow to embark upon any new enterprise.

Cocoa, at three years old, begins to yield, and there is no prettier sight than a cocoa tree bending under its weight of massive bright pods. The cultivation is very simple, and the preparation on the estate consists in removing the beans from the ripe pod, and drying them sufficiently for safe shipment to European markets. When the beans reach the factory they are ground, roasted, and husked, and they can either be procured in the pure form of cocoa nibs, or in one of other of the many preparations of cocoa, after some of the fat, of which cocoa beans contain 50 per cent., has been extracted. This cocoa fat, or butter, which has a remarkable power of not becoming rancid, would be used for many manufacturing purposes if it were procurable, but, meanwhile, it is chiefly taken up in the composition of chocolate cream and sweetmeats of various kinds.

Though the consumption of cocoa—as custom requires us, though inaccurately, to spell it—is increasing, the increase is but slow; it is far the most nutritive of all non-alcoholic stimulants, and deserves a far higher place as an article of food.

ADULTERATION.

Medical testimony is almost unanimously in favour of the moderate and judicious use of tea, coffee, and cocoa, and the criminal statistics of the country show how great a social and moral reform the substitution of these wholesome non-intoxicant stimulants for deleterious intoxicants has effected, but much remains to be done, for while there are no more pleasant and nourishing beverages than good tea, coffee, or cocoa, there are no more nauseous compounds than the beverages frequently sold and supplied under their names

Those whose means permit of the purchase of tea in chests straight from the plantations, or of the treatment at home of raw coffee or cocoa nibs, should have no difficulty in securing excellence, but the vast majority are compelled to buy these articles ready for use, and are thus practically in the hands, and at the mercy, of the tradesmen who supply them. Coffee has been at all times much adulterated, but since the mixture and sale of chicory and dandelion root with coffee was legalised in 1882, and under the shield of a Government stamp, it became permissible to sell any rubbish as a coffee mixture, the steady decline in the consumption of coffee showed how detrimental that legislation has been to producer, consumers, and revenue. Recent analyses of so-called coffee showing in many cases a mere trace of coffee, prove the utter demoralisation of the trade; and as the unit of coffee may, for purposes of comparison, be taken at 1s. 3d., and the unit of chicory and the numerous other adulterants at 3d., it is obvious that it is directly against the tradesman's interest to sell pure coffee. It is not because coffee is scarce, or for want of purchasing power, because the Dutchman drinks more than 20 lbs. per head, and taking 3 lbs. of coffee as supplying the same quantity of beverage as 1 lb. of tea, Holland consumes more of the allied beverages than the United Kingdom.

The shameless adulteration of coffee with all sorts of vegetable and even animal substances is so freely carried out, that even the legitimised and, at all events, harmless chicory is in itself much adulterated. What should be one of the greatest competitors in the race against alcohol has been virtually scratched, and a generation is growing up which knows not what coffee means. The various preparations of cocoa are composed largely of arrowroot and other starchy subtances, many of them containing but a flavouring of cocoa, and it is this admixure of uncooked starches which gives rise to he prejudice that this most valuable article of food is difficult of digestion.

The enormous expenditure incurred in advertising leads to the belief that the Customs tables are no gauge of the quantity of food consumed under the names of coffee and cocoa, and in addition to the 10,000,000 lbs. of imported chicory, it would be interesting if it were possible to learn how many pounds of British chicory and dandelion root, of starches, roasted grain of all sorts, and vegetable refuse generally, the British public unconsciously imbibe.

The free breakfast table is admirable in theory. The pure breakfast-table would be ten times more beneficial, and is far more practicable. Customs vigilance has almost stopped the importation of adulterated tea, though much comes into consumption which, though not condemned as unfit for human food, is entirely lacking in the pleasant and stimulating qualities which good tea possesses Inferior teas, often the mere sweepings of Chinese stores are passed into consumption with a label such as this—

"PURE CEYLON TEA"
Blended with China.

in which "blended with China" is almost invisible, much to the detriment of the British tea growers, and much to the loss of the consumer who, if his palate and his patience will allow him to consume a packet observantly, will find at the end that he has been drinking an unpleasant and, to him, an unprofitable thing at a greater cost per cup than he could have got a good article for, because he requires to use so much even to impart a decent colour. Another legalised trade practice constantly perpetrated is the adoption upon packets of a name very closely resembling that perhaps of a well-known plantation in Ceylon; and with the object of checking this, the honest dealer or the anxious consumer can always find out at the office of the Ceylon Association in London whether such names are genuine or not.

THE TEA DUTY.

The tea duty is a question so nearly one of party politics, that this is not the platform upon which to discuss it; but I shall, in a few words, point out the present effect of the duty, and how a reduction or abolition might act. The duty, sixpence per pound, which brings £4,600,000 into the exchequer, falls, of course, proportionately, so much more heavily upon low than upon high-class tea, that it offers a premium to the importer to send in good tea; and while the adulteration of coffee or cocoa beans is easy of detection, a dried and rolled-up leaf is more liable to spurious imitation; besides, tea requires special protection against itself, for the leaves which have been once used can be rolled up again, and as has been before pointed out, it is only the very young shoots which possess the necessary properties to make good tea. A vastly increased quantity of tea might be made by waiting until the leaves got older, but then they would be defective in all the qualities which constitute good tea. Reduce this premium and the proportionate Customs vigilance, and you reduce the incentive to produce good tea. Remove them, and you go a step further, and though it would at first sight seem that a reduction of duty would be favourable to both producer and consumer, I believe in this case the effect would be directly opposite.

It is doubtful whether a reduction of duty would be followed by largely increased consumption, because the average retail price of tea is probably threepence or fourpence per pound less now than it was four years ago; but consumption remains almost stationary, though, as the Chancellor of the Exchequer has twice pointed out, the increased consumption of Indian and Ceylon teas mean, on account of their greater strength, an increase in number of cups of tea, and the standard of much of the tea which reaches the poor is already so low that, as an article of human food, it is absolutely valueless. The immediate effect of reduction or removal of duty would be that a large quantity of refuse tea, which the Chinese decline to consume themselves, would be forced on the market to the detriment of the British tea grower, who, whether in India or Ceylon, has invested largely in machinery or appliances for manufacturing good tea. The secondary result of reduced Customs vigilance would be that the hedgerows of Southern Europe would largely contribute to the breakfast-tables of England, and then the tea market would become so demoralised that if it was treated by Act of Parliament as coffee has been, admixture would be legalised, and beech tea, sloe tea, and a hundred other teas would be freely sold, and with the death-knell of coffee still ringing in our ears we should await the doom of tea.

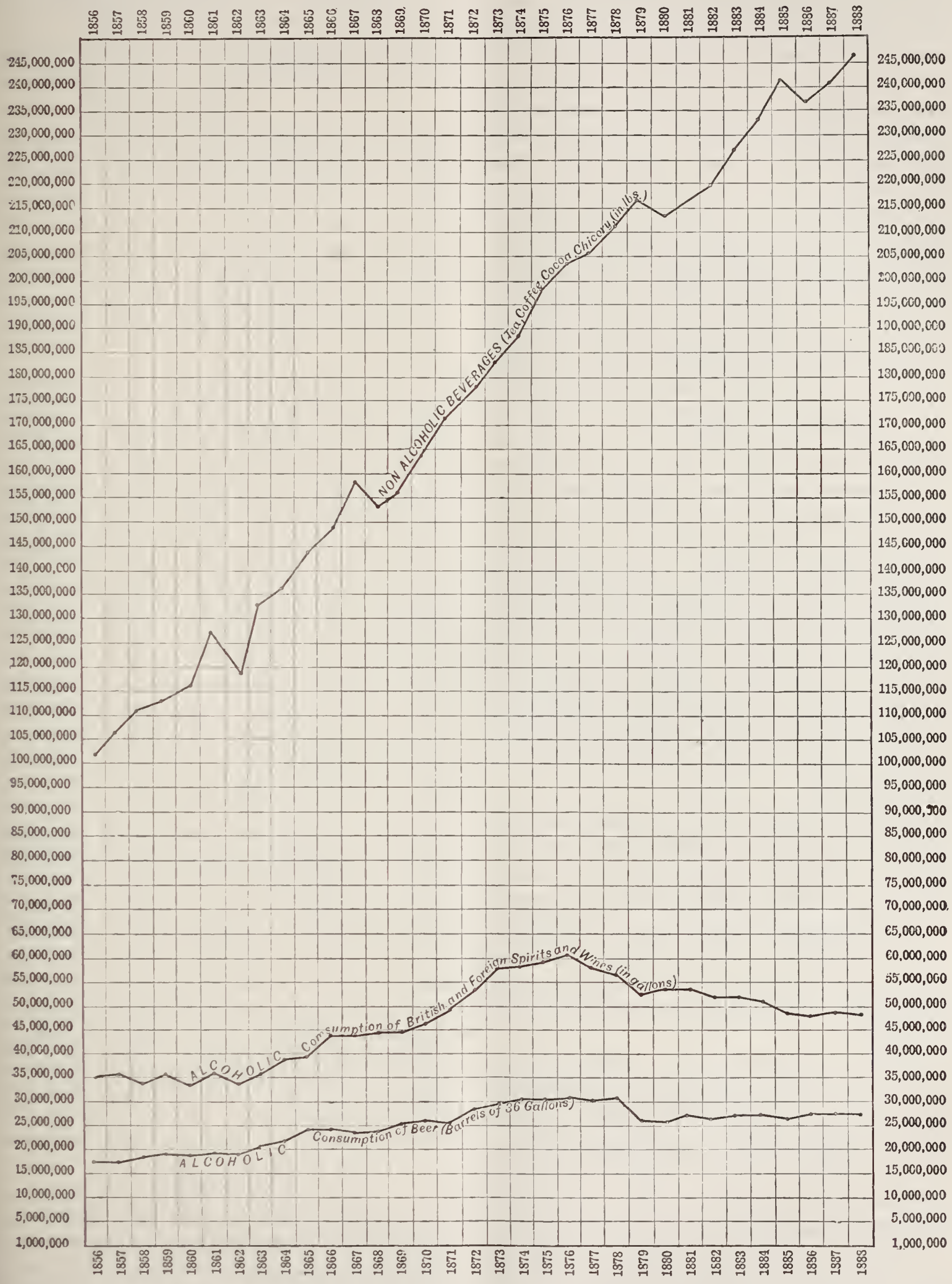


CHART SHOWING CONSUMPTION OF ALCOHOLIC AND NON-ALCOHOLIC BEVERAGES FROM 1856 TO 1888.

When I was honoured with an invitation to read a paper before this Society I hesitated, my first thought being, What can I say that has not been more ably said before?

Believing, as I do, that Imperial Federation can only be firmly founded on mutual commercial advantage, and that the extension of knowledge is the first step towards federation, I gratefully accepted the opportunity of drawing attention to great colonial industries. And how rapid the changes in these industries are! When the Ceylon figures were compiled for the Colonial and Indian Exhibition, but four short years ago, the maximum export shown was 3,796,884 lbs., and this year we have to deal with more than 40,000,000 lbs. In 1885, the consumption of British-grown tea was 38 per cent. of the total, last year it was 67 per cent.; and this displacement of China tea by British-grown tea means a very large annual draft upon the mother country for machinery, lead, iron, and many other articles of British manufacture, besides a large bill for piece goods of various kinds, the clothing of the million and a half British subjects directly depending on tea cultivation.

The Indian and Ceylon tea industries represent an investment of British capital of probably £30,000,000 sterling, and to possess within ourselves the power of producing and consuming is our very strongest Imperial bond, though so far but very scantily recognised. A description of special industries in special localities is necessarily narrow and lacking in general interest, but I venture to think there is much in the agricultural history of Ceylon capable of profitable application to other parts of the Empire.

There are lessons to be learned from the failure of coffee, and the various products which succeeded it, which may directly benefit many parts of our tropical empire, and there is the great general lesson from which all may learn teaching how the planters of Ceylon manfully met difficulties which seemed once insuperable, and by their efforts have restored prosperity.

I append to these remarks a Table showing the average consumption per head of population of our non-alcoholic drinks, and the progress they have made; and while the figures for 1889 show tea and cocoa as almost stationary, there is again a considerable falling off in the consumption of coffee and chicory. I specially commend to the workers among the poor the task of raising the standard of these drinks, and I trust my brief and necessarily imperfect sketch may stimulate interest in colonial enterprise, and tend to the fulfilment of the moral obligation which the mother country owes the colonies.

STATISTICS AS TO THE NON-ALCOHOLIC DRINKS OF THE PEOPLE OF THE UNITED KINGDOM.

POPULATION.		AVERAGE CONSUMPTION PER HEAD OF POPULATION.			
Years.	United Kingdom.	Tea.	Coffee.	Cocoa.	Total.
		lb.	lb.	lb.	lb.
1856....	28,011,034	2·26	1·25	·13	3·64
1857....	28,188,280	2·45	1·22	·09	3·76
1858....	28,389,770	2·58	1·24	·10	3·92
1859....	28,590,224	2·67	1·20	·11	3·98
1860....	28,778,411	2·67	1·23	·11	4·01
1861....	28,974,362	2·69	1·21	·12	4·02
1862....	29,255,015	2·70	1·18	·12	4·00
1863....	29,433,918	2·90	1·11	·13	4·14
1864....	29,628,578	3·00	1·06	·13	4·19
1865....	29,861,908	3·29	1·02	·13	4·44
1866....	30,076,812	3·42	1·02	·14	4·58
1867....	30,334,999	3·68	1·04	·14	4·86
1868....	30,617,718	3·52	1·00	·17	4·69
1869....	30,913,513	3·63	·94	·19	4·76
1870....	31,205,444	3·81	·98	·20	4·99
1871....	31,513,442	3·92	·97	·23	5·12
1872....	31,874,183	4·01	·98	·24	5·23
1873....	32,177,550	4·10	·99	·26	5·35
1874....	32,501,517	4·22	·96	·27	5·45
1875....	32,838,758	4·43	·98	·30	5·71
1876....	33,199,994	4·49	.99	·31	5·79
1877....	33,575,941	4·50	·96	·30	5·76
1878....	33,943,773	4·64	·97	·29	5·90
1879....	34,302,557	4·68	·99	·29	5·96
1880....	34,622,930	4·57	·92	·30	5·79
1881....	34,952,204	4·51	·89	·31	5·78
1882....	35,297,114	4·67	·88	·34	5·89
1883....	35,611,770	4·80	·89	·36	6·05
1884....	35,961,663	4·87	·90	·39	6·16
1885....	36,331,119	5·02	·90	·40	6·32
1886....	36,709,409	4·87	·86	·41	6·14
1887....	37,091,564	4·95	·81	·43	6·19
1888....	37,440,505	4·95	·82	·49	6·26

DISCUSSION.

MR. HYDE CLARKE said the paper dealt so exhaustively with the subject, that no one not being a specialist, or connected with the island, could venture to add anything to it. It was very gratifying to listen to such a paper, which gave the whole history of the subject from the beginning, and dwelt especially upon its most interesting aspects, showing the benefits which had been conferred on the local population on the one hand, and on the other the way in which the enterprises referred to had made an opening for numbers of young men in England, who, after spending some years in Ceylon, had come home to enjoy the prosperity which they had acquired by their enterprise and energy, and to spend the remainder of their lives in their native land. One very interesting feature, though a melancholy one, was the history of the coffee industry, the failure in which, however, was not limited to Ceylon, for in many parts of the world similar plagues had made their appearance in such virulence that all the coffee trees had to be rooted up as the only means of checking the progress of the disease. Happily, however, their countrymen in Ceylon, when their efforts were foiled in one quarter turned to another, and had raised the production of tea to such a height of prosperity, that the history of the cultivation was almost a romance. He cordially congratulated Mr. Shand on his paper.

Mr. FOLKARD said all who were connected with Ceylon ought to feel indebted to Mr. Shand for mentioning so prominently the question of the possible reduction of the tea duty, which many people hoped might be announced in the forthcoming Budget. He thought those who considered the matter from all points of view would agree with Mr. Shand in his conclusions. Sir Roper Lethbridge had recently addressed a letter to the *Times*, in which he enunciated very much the same views; but though he perfectly agreed with both Mr. Shand and Sir Roper Lethbridge, there was another way of looking at it, and a correct judgment could only be arrived at by considering the the various parties engaged in the business. He had been informed lately by a gentleman who had made inquiries on the subject, that the general price of the tea sold in the poorer districts in London and the country was 1s. 8d. Of that 4d. was the retailer's profit; the intermediate dealer, who purchased in Mincing-lane and supplied the retailer, required 5d. per lb., and sometimes 6d., which reduced the price to 10d. or 11d., from which, after deducting the duty, you only had 5d. remaining as the original price of the tea which was retailed at 1s. 8d. Very few dealers could purchase decent Ceylon or Indian tea at that price, and therefore they must be content with the cheapest varieties from China, which were sold at 4d., 4½d., and 4¾d. The result was that Ceylon tea, as a rule, never reached the mass of the people at all, but was consumed by those who could afford to give 2s. or 2s. 6d. per lb. The duty, therefore, might be said to keep the poor from purchasing Ceylon tea. But there was another way of looking at it. If 6d. a lb. were taken off altogether, the cheap China tea could be sold to the poor at 1s. 2d., but the Ceylon tea would have to be charged at least 3d. a lb. more, and the question was whether the poor would recognise that it was worth fully 3d. a lb. more in flavour and strength, and be willing to pay the entire price. The per-centage of difference between the two qualities would be greater with the duty taken off than with it on, and therefore he supported Mr. Shand's view that if the duty were removed, Ceylon tea would be handicapped more than it was at present.

The CHAIRMAN, in proposing a vote of thanks to Mr. Shand, said he must refer for a moment to the efforts which that gentleman was making to introduce Ceylon tea into Paris, where the tea sold was generally more horrible than could be imagined, and the price charged was enormous. Another question in which he was much interested as a teetotaller was that of good temperance drinks, and his experience was that cold tea was the very best drink of all. On that ground also he had reason to wish success to Ceylon tea and Indian as well. If the Chancellor of the Exchequer would help them in the tea business, he would assist the teetotallers and counteract the harm which he feared Mr. Gladstone had done by the grocers' licenses. He concluded by moving a hearty vote of thanks for the paper, which did great credit to the Section.

The vote of thanks having been passed

Mr. SHAND, in reply, said they could not expect to make the French a nation of tea-drinkers all at once, but he was much indebted to the Secretary for placing means at his disposal which enabled him to introduce Ceylon tea to the Parisian public. He had no doubt that good results would follow, but they could not expect these to be seen immediately, as was the case with the Indian and Colonial Exhibition of 1886, the success of which was so much due to the exertions of the Chairman. That Exhibition created for many of them an era they would never forget, and they all owed a deep debt to Sir Philip Cunliffe-Owen for the zeal, energy, and courtesy which he displayed in connection with it. He was sure that if Sir Philip could tear himself away from South Kensington for a time and pay a visit to Ceylon, he would find that his fame had preceded him, and that he would receive a most cordial welcome.

SEVENTH ORDINARY MEETING.

Wednesday, January 22nd, 1890; Sir DOUGLAS GALTON, K.C.B., D.C.L., F.R.S., Vice-President of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Holt, Horace Henry, 17, Parliament-street, S.W.
Reynolds, Dr. John, 369, Coldharbour-lane, Brixton, S.W.
Whitwell, William, Thornaby Iron Works, Stockton-on-Tees, and Overdene, Saltburn-by-the-Sea.

The following candidates were balloted for and duly elected members of the Society:—

Bull, J. G. Cuthbertson, Bloomsbury-mansion, Hart-street, W.C.

Copperthwaite, Harold, York.
Money, Robert J., care of T. W. How, 35A, Great George-street, S.W., and Puerto Cabello, Venezuela, South America.
Scott, Ronald A., The Elms, Acton-hill, W.

The paper read was—

PRACTICAL VISION-TESTING.

By R. Brudenell Carter, F.R.C.S.

The suggestion that I should bring before the Society of Arts a paper on "Practical Vision-Testing," arose from the familiar fact that there are many industries in which good vision is essential, not merely to excellence of workmanship, but also the security of numerous person who are dependent, as in the case of passengers in a train or in a steamship, upon the prompt recognition of signals by those whose duty it is to control the helm or the locomotive. On this account it has been found necessary, by railway directors, shipowners, and other employers, to establish tests for visions of various kinds, as conditions to be satisfied by those seeking to obtain or to retain employment in various capacities; and this private action has been endorsed by that of the department of the Government which is intrusted with the supervision of locomotive facilities. The tests and examinations thus instituted have been modified from time to time, sometimes in accordance with increasing knowledge, and, sometimes, it may be feared, as a result of ignorant submission to clamour. Of late, especially, we have heard a good deal to the effect that the tests and methods of employing them adopted by railway companies have become "unsatisfactory;" and demands for alteration have been made, with threats that these demands would be supported by the machinery of a "strike," if the alterations asked for were not speedily carried into effect. The complaints have been based chiefly upon the following statements:—First, that the tests of form-vision and of colour-vision commonly employed are in themselves insufficient and misleading; secondly, that their deficiencies have been intensified by their having been applied in an imperfect manner or by incompetent persons; and, thirdly, that they have been used, by foremen and others, for the purpose of improperly dismissing or reducing workmen against whom those so using them entertained a grudge. It is asserted that this latter object has been attained by calling upon the workmen to submit to vision tests when they were exhausted by labour, as, for example, in the case of an engine driver, when he had been for 17 hours upon the footplate.

It is obviously impossible for me, in such a paper as the present, even to consider how far such an allegation as that last mentioned may be founded in fact; and I must be content with the endeavour to lay down, and, in the very imperfect way which time will allow, to explain, the principles on which trustworthy vision-testing, whether for form or colour, should be conducted. I may premise, however, that similar complaints have arisen in America, and that there they have been clearly traceable to the circumstance that the tests employed have been real and searching, and have actually excluded from certain kinds of occupation, persons who were manifestly unfit to engage in them. An engine driver, for example, with defective vision may, nevertheless, get through his work for a long period without accident, having acquired, perhaps, a certain skill in the interpretation of imperfectly seen appearances. Notwithstanding this skill, which does not admit of being estimated or valued, he is nevertheless an unsafe man, who by any trustworthy test would be removed; and, if he remain in his employment, the probabilities are that some day his defect will find him out, and will lead to a disastrous accident. The determination of some of the American companies, and of some of the State Legislatures, to permit no risks of this kind, and to remove men who, although they had driven without accident, were, nevertheless, constantly liable to error, created much dissatisfaction in the States, and, in some of them, this dissatisfaction was used as a lever by one or other political party, who sought to obtain the votes of railway men by promising to agitate for an alteration in the laws by which the obnoxious tests were imposed.

It is intelligible enough to the student of human nature that every engine driver, although quite ready to admit that good vision is essential to his calling, would none the less be prepared to affirm that his own personal vision was at least good enough, and that any test which showed it to be deficient was misleading. There are some who would go farther still, and who appear to entertain very lax views with regard to the duties to the public which the pursuit of certain occupations would generally be held to entail. Not long ago a man with very bad eyes came to me at St. George's Hospital. His eyes were in such a state that he was not only nearly blind, but that shelter and treatment as an in-patient were necessary to his recovery. I told him that he must remain in the hospital, but to this he strenuously objected, on the ground that it was necessary for him to continue his work and to earn his living. On inquiring the nature of this work, I found that he was the driver of a Hansom cab in London; an occupation in which he could then only have been saved from collisions by the sagacity of his horse. I was sorry for the poor fellow, but recognised a duty to the public; and told him that if he attempted to return to his driving seat, I should feel it right to communicate with the police. He yielded, and I had the satisfaction of sending him out cured; but the case was a warning to me not to attach too much importance to a workman's own impression with regard to his physical fitness for any duty in which he might be anxious to engage. I am, therefore, prepared largely to discount some of the complaints to which I have referred; and to believe that the accuracy and excellence of any given test may sometimes be a reason for fault-finding on the part of those who think that it presses upon them with undue severity.

I have received, since this paper was announced, a communication from a gentleman who has greatly interested himself in the subject, and who advised me to inquire as to the methods of testing which are in use upon some particular railway (I forget which), because, he said, they were satisfactory to the men. Now I wish to point out that, in order to be able to estimate the value of a vision test correctly, to know when and to what extent it is trustworthy, and in what circumstances it would be likely or certain to break down, it is necessary to be fairly well acquainted with both physical and physiological optics. The satisfaction of a railway man, I care not whether the chairman of the company or the driver of a shunting engine, would have no influence in rendering a deceptive test trustworthy, or in rendering a trustworthy test deceptive. The opinion which either might express would have no influence upon the instructed judgment of an expert. It is no doubt desirable that railway men should know that they are fairly dealt with; but they must derive this satisfaction, if at all, at least on this question, from their confidence in the character and attainments of those by whom the examinations are conducted. It would be absolutely impossible, as a rule, for men following a laborious business to devote to the study of optics such an amount of time and attention as would be required in order to qualify them to act the part of critics. It is mainly for this reason, but also for many others, that, even if routine portions of the examination are sometimes committed to a clerk or other such official, the men whose employment is at stake should always have an opportunity, in case of need, of appealing to the decision of a trained and thoroughly competent examiner. There is no particular charm in his being a doctor, for many doctors have never attempted to master the questions at issue; but he should certainly be well acquainted with optics, and should be a person not only of intelligence but of high mental cultivation.

The vision which we are called upon to consider depends upon two perfectly distinct elements; namely, the power of seeing the shape or outline of an object, and the power of seeing its colour. It is necessary to consider these apart from one another.

The eye is an instrument which bears a general resemblance to a photographer's camera, and which, like it, produces upon its background a reduced and inverted image of the visible objects towards which it is directed. But the background of the eye, instead of being of ground-glass, like that of the camera, is an infinitely fine mosaic composed of the terminations of sensitive nerve fibres, each of which is endowed with independent sensibility, and each of which conveys to the brain the impression produced upon it by that part of the general image which itself receives; the brain then combining these separate impressions, or reports, as they may be called, into an effect upon the consciousness which is so interpreted as to afford information about the nature of the visible object. The sense of touch is less fine than that of the sight, but its mode of action is more familiar, and may serve to illustrate that of the former. If I place one finger-tip upon the surface of a coin, I shall feel that surface, and may perhaps recognise its metallic character. If I place the tips of five fingers upon the coin I shall, by combining the impressions which they receive, recognise its circular outline, its magnitude and thickness, and also something of the difference between its own surface and that upon which it rests. The consciousness hardly analyses the impressions received by the five fingers, and is hardly aware of their distinctness, but it combines them to form the basis of a single mental operation. In like manner, although the impression made upon each separate nerve-fibre forms the basis of the sense of vision, we have become habituated to combining these impressions without analysing them, although if we desire to understand how seeing is accomplished, it is the action of the single fibre to which our attention must in the first instance be directed. Now this action, disregarding colour, and for the present confining ourselves to form, is that some given nerve fibre receives more or less light than those around it, and is impressed by the difference, which, in order to create the impression, must be of a certain amount. Each fibre, in an isolated condition, is circular in outline, but these circular outlines, when closely packed together, necessarily become hexagonal, and we may take this diagram as representing, on an enormously enlarged scale, the surface on which the visual image is received. It must be remembered that each nerve terminal is capable only of taking account of the difference between the amount of light which falls upon it and that which falls upon its neighbour, but that no nerve fibre can take account of differences of illumination which affect different parts of its own individual surface. Let us suppose that the object looked at is circular, say one of these dots, which furnishes, of course, a circular image upon the retina. If the image be so small as to fall wholly within the boundaries of a single hexagon, as at A, that nerve fibre alone will be affected. If it be large enough to transgress the limits of that hexagon, and to extend, in however slight a degree, upon the surrounding ones, they will all be affected like the central one, as at B.

Now the size of the retinal image depends upon two elements, the size of the object looked at and its distance, these two together regulating the dimensions of what is called the visual angle. Time will not permit me to go into details on this question, and I must be content to say that the retinal image of this spot, seen from a distance of fifty yards, would be precisely the same as that of this one, seen from a distance of twenty-five yards. It is clear that by altering the distance of the same object we may obtain from it an image which extends over several hexagons, or which is just contained within the limits of a single one, or which covers only one-third, or one-sixth, or any greater or less proportion of the area of a single one. Let us take a case in which the image is definitely smaller than a single hexagon, and let us suppose that the object which furnishes the image is either a dark spot, like one of these, or a bright spot, such as a fixed star. In the former case, the affected hexagon will receive less illumination than its neighbours, in the latter case it will receive more. Now it is evident that the amount of this difference must reach a certain degree before any given eye is able to recognise the presence of a dark or of a bright spot, as the case may be; and it is also evident that the degree may differ in different eyes, some having a greater or less degree of acuteness of light perception than others. We all know that as twilight passes into darkness stars suddenly become visible. There is no difference in the visibility of the star, or in the amount of light received from it; but, as that amount contrasts more and more strongly with the surrounding gloom, the difference between the hexagon which receives the star image and the surrounding hexagons becomes greater, and at last becomes great enough to be recognisable. In these circumstances, one person will see a particular star before it becomes visible to another. Arago met with a Siberian Tartar who was able, with the unaided eye, to see the third satellite of Jupiter, which has probably never been so seen by any European. This kind of seeing, however, is not a result or a measure of acuteness of vision, properly so called, but only of acuteness of light perception, that is, of the power of recognising small differences in the quantity of light which is received on different parts of the retina, or upon different hexagons of its surface. In order to arrive at acuteness of vision, properly so called, we have to ascertain the power of the person tested to see separateness, to see, that is, whether a certain bright or dark object is single or multiple, composed of a single spot or of two or more spots. Now, in order to see the separateness of a group of spots at the greatest possible distance, or in order to count the number of which it is composed, it is requisite that the interval between each two of them should not be less than the diameter of the spots themselves, and then the image on the retina must be of such a size that the image of no single spot transgresses the limits of a single hexagon, the result of this being that the hexagon intervening between any two which are impressed remains unaffected, and so produces the impression of the clear interval which separates them. The moment the object is removed to so great a distance, in proportion to its size, that there is no longer an unaffected hexagon left between two spot images, that moment the two images become blended into a single one, and their distinctness can no longer be recognised by the eye. It is obvious that, the finer the retinal mosaic, the smaller the individual hexagons of which it is built up, the greater will be the distance at which the separateness of the individuals of a given group of spots will be discerned; and it is also obvious that this distance might also be increased by increasing the intervals between the spots themselves without increasing their diameter. It follows that the most accurate test of visual acuteness is obtained by using groups of spots, each one of which is separated from its neighbours by intervals equal to its own diameter. The distance from the observer, or person tested, at which the number of spots forming such a group could be distinctly recognised, would vary within uncertain limits with different people, and it has been found necessary, for practical purposes, to set up a standard which is fairly expressive of average human capacity. It would take me too long if I were to explain the theoretical considerations by which, as well as by practical observations, this standard has been arrived at, but I am able to place it before you. Its requirements are fulfilled when the spots which form this group are correctly counted at a distance of 50 metres, and when these are correctly counted at 25 metres, or these at 10, the magnitude of the retinal image being precisely the same in all three cases. It is understood, of course, that the trial should always be made in good daylight, and that the person tested should be so placed as not to be dazzled or hindered by the direction in which the light falls. Printed types, of regulated sizes, are much used for vision-testing, and answer fairly well for many purposes, but they are inferior, in the accuracy of the results which they afford, to those groups of spots which correspond with the anatomical structure of the retina, and leave absolutely nothing to be desired. The dots used in the army are very imperfect contrivances, and the results which they afford are not trustworthy. They are of square shape, so that their square images easily transgress the hexagonal boundaries of a nerve fibre, and they are separated by uncertain and usually by too great distances, so that they are rendered more distinct than they should be, and differently distinct according to the distances between them.

The best mechanical arrangement for testing vision by groups of dots is to have a series of these groups placed in a circle near the margin of a revolving wheel, which again is placed behind a disc with a marginal aperture of such a size as to disclose only group at a time. The person to be examined is placed at the proper distance, in proper light, and the disc is turned round. As each group of dots is disclosed the person tested should name the number of dots composing it, rapidly and without mistake. Whoever can do this has normal vision. He might not be able to see one of Jupiter's satellites, but he would see, in all circumstances, everything which could be seen in the same circumstances by any ordinary person.

If the examinee should make mistakes, the next step is to allow him gradually to approach the dots, until he reaches a distance at which his mistakes cease. The difference between the distance at which he ought to see and the distance at which he can see, permits the degree of acuteness of vision which he possesses to be stated in a fraction with absolute accuracy. If he ought to count the dots at fifty metres, and cannot until he comes to twenty-five, his vision is fifty divided by twenty-five, or exactly one half of what is normal. If he comes to thirty metres, his vision is three-fifths of the normal.

Now normal vision, as thus defined, is, for the average man, the practical limit of human faculty, and it is the business of the ophthalmic expert to declare when this limit is attained, and also by how much any given examinee may fall short of it. It is the business of the railway expert to declare what amount of vision is sufficient for his requirements. It may be—I do not say it is, but it may be—that half-vision or three-fifths vision would enable an engine driver to discharge his duties in a safe and satisfactory manner. That is for the railway authorities to decide. The man with normal vision will see a day signal at the greatest distance at which it is visible, the man with three-fifths vision will not see it until he arrives within three-fifths of that greatest distance, the man with half-vision will not see it until he arrives within half that distance. It is obvious that the two last-named men would be liable to lose time in putting on brakes in the case of an impending collision; but it is conceivable, of course, that the time allowed for this purpose by normal vision would always be more than could be required. It is certain, I think, that few signals come into view, on account of curves or other impediments to sight, at the full distance at which they would be visible if no such impediments existed.

When the ophthalmic expert has decided that a given examinee has less than normal vision, he has yet another function to discharge, which is to determine the nature of the cause by which the defect is produced. Roughly speaking, there may be three causes, or at least one of three, in operation. Vision may be rendered imperfect by defective action of the nerve, or by turbidity in parts of the eye which ought to be transparent, or by faults of shape or curvature. The first two conditions, generally speaking, are only remediable, if at all, by medical or surgical treatment, the third is often remediable by glasses. Here again, therefore, we have to call upon the railway expert to decide whether the occupation of the workman is one in which glasses may safely be employed. It must be remembered that, setting aside ignorant prejudice, the vision obtained by the help of glasses may be just as good as any that is possessed without them; but, on the other hand, there are two possible objections to their use. In the first place, if good vision is required from a worker exposed to weather, as from a sailor, glasses are wholly inadmissible, because they would frequently be rendered cloudy and useless by rain or spray. They would be inadmissible therefore, I think, on the unprotected footplate of an engine, but quite admissible where the driver was protected by the covering which is now usually supplied to locomotives. Even here, however, the use of spectacles is open to the objection that they are liable to be broken or forgotten, and that a man who is perfectly useful and trustworthy with them, is liable to be rendered useless and dangerous by being accidently deprived of them. On this ground, it again becomes a question for the railway expert, how far he is justified in committing the charge of a train to a driver who is dependent upon an adventitious aid of which he is liable to be deprived. The military authorities will not give commissions in the army to candidates whose unaided vision falls below one-sixth of the normal, and it would perhaps be possible for railways to adopt some similar rule. It is manifest, I think, that the decision of employers on such a question would probably be much influenced by the supply of capable candidates with no infirmities requiring correction. Where men with good vision are plentiful it is obvious that men with defective vision must be heavily handicapped.

It is worth while to refer for a moment to one form of defective vision which may admit of complete correction by glasses, but which, if uncorrected, would be especially dangerous for an engine driver. The defect in question is called astigmatism, and consists in the unaided sight being unequally acute for lines in different directions. For example, a man may have natural sight for a vertical line, and yet be shortsighted, even in a high degree, for a horizontal line. Such a man would see perfectly the upright standard of a signal post, even at full normal distance, but he would be unable to see the horizontal arm of the signal until he came much nearer to it. His vision would be at once detected as below the standard by the groups of spots, and might probably be raised to the standard, or nearly so, by glasses; but still, without glasses, he would be a very unfit person to be put in charge of a locomotive.

I may now pass on to the second branch of the subject, which owes its importance to the fact that it is necessary to render both railway and marine signals visible at night, and that, for this purpose, we have no other available means than coloured lights, and no other generally available colours than red and green. Unfortunately, however, nearly 4 per cent. of the male working population of this country are possessed of only imperfect colour vision; and hence are liable to make mistakes in the colours of the lights thus displayed to them. We shall best approach the consideration of their difficulties if we first inquire what colour blindness means, and upon what conditions it appears to depend.

Before such an audience as this, I need not dwell on the fact that what we call light is a sensation produced by the vibration of ether waves entering the eye, or that what we call colour is a sensation produced by the rapidity of the wave movement. We say of sunlight that it is white or colourless, but we easily determine experimentally that it is composed of waves of three definite magnitudes, three definite rates of vibration, and, as we say, of three different colours—red, green, and violet. Of these, the red light—which, when sunlight is passed through a prism, falls to the least refracted end of the spectrum—is composed of waves of such magnitude that it would require 36,918 of them, placed end to end, to cover one inch; while the extreme violet is composed of rays of which 64,631 would be required to cover one inch, the magnitude of the green waves being intermediate. The general velocity of mixed or white light being, roughly, 190 millions of miles in a second, it follows by a simple calculation that, when the eye is looking at pure red, it receives 451 millions of millions of waves in that period of time, and that, when it is looking at pure violet, it receives 789 millions of millions in the same period.

Now, the power of seeing light depends upon the communication of its wave movement to the fibres of the optic nerve, and it follows that no light is visible unless its wave movement is thus communicated. In the case of each nerve fibre, there are limits to the rates of vibration which it is able to pick up or to respond to. We are familiar with similar limits in the case of sound. A tuning-fork or a tuned string will only respond to—that is, will only be influenced by—rates of vibration with which it is in unison. If we have a series of tuning-forks, and if we throw one of them into vibration, all those which are in unison with it will vibrate also, while those which are not in unison will remain mute. The average human ear is capable of vibrating in unison with, or, as we say, of hearing, sound waves which cover a range of about eleven octaves, but there are great individual differences at both ends of the scale. Some persons can hear a deeper note than others, some persons can hear a higher note than others. Analogous differences exist between different eyes with regard to light, but in all eyes the range of capacity is much smaller than in the case of the ear, and only covers the equivalent of about a single octave. The actual wave movement of light extends considerably beyond the limits of the visible spectrum. There is an active wave movement here, outside of the extreme red, which is attended by heat, but which is invisible. There is an active wave movement here, to the outside of the violet, which excites some kinds of chemical action, but which is invisible. The retina contains no fibres in unison with, or capable of being affected by, either, and it can easily be demonstrated that the limits of visibility in the spectrum, like the limits of audible sound, vary in different eyes. Some persons see more or less red, some see more or less violet, than is usually visible; and, in either case, without departure from the commonly recognised conditions of ordinary seeing.

Besides these differences there are others, of a comparatively exceptional kind, which depend upon an incapacity, in the nerve fibres of some eyes, to vibrate in response to waves which, by the great majority, are responded to readily. I have already explained that the red end of the spectrum appears shorter to some persons than to others, that is to say, that the slowest and largest waves fail to call some nerve fibres into corresponding vibration, just as some ears fail to catch the deepest notes which are audible to others. Carry this incapacity to respond to large slow waves a little farther, and we have incapacity to respond, not only to the pure or extreme red, but also to red the wave movement of which is beginning to be modified by green. The red waves which enter the eye do not excite the nerve fibres to the usual vibration, that is, they do not produce the customary sensation, and the person does not see red, but is completely or incompletely "red-blind." In looking at the spectrum, if it were anywhere of a pure red, he would not see that portion, but would see only the surface of the screen on which the spectrum was thrown, as if the spectrum were not there. But, in ordinary conditions, there is no such thing as pure red, which can only be obtained, for experimental purposes, by very carefully devised contrivances. Even in the spectrum, in which all the shades of orange and yellow are produced by a varying amount of overlapping of the red by the green, the green runs decidedly into portions which most people would call red, and reaches, in some small degree, even to the ordinarily visible extremity. The arrangement is something like that shown in the diagram on the wall, in which red enormously preponderates at one end of the spectrum, green in its central portion, and violet at the other end, but in no case to the absolute exclusion of the other colours. Artificial light, except electric light, differs from sunlight chiefly in being poor in violet, but contains almost the same relative proportions of red and green. If we look at the ordinary red lamp of a train we shall usually see in the centre of the red circle an outline, more or less conspicuous, of the flame which is behind the red glass, and this flame will appear yellowish or orange by comparison with the outer portions of the red circle around it. The reason is that the glass, although we call it red, still transmits a portion of green light, which, blending with the red, produces a yellow or orange tint where it is most pronounced; and a person who was absolutely red-blind, looking at such a lamp, would see it by virtue of the green rays which it suffered to pass. It would not be invisible to him, but would present a certain degree of luminosity, and a certain appearance. This appearance would differ from that of a green lamp, in which the preponderance of green rays would be modified, as far as ordinary specimens of glass are concerned, by a certain admixture of violet. Precisely in the same way, a person who was green-blind—and there are such, their optic nerves being incapable of making the ordinary response to the impact of the green waves, which possess an intermediate magnitude and rapidity—would, nevertheless, not lose sight of a lamp with a green glass, but would see its luminosity by virtue of the colour other than pure green which it transmitted. There are also persons who are violet-blind, whose nerves will not respond to the small and rapid waves at the violet end of the spectrum, but this defect is very uncommon, and is of little or no practical importance. Red and green lights are those which are used in railway and marine signalling, and the chief practical object of testing colour-vision is to ascertain whether the person tested is normally capable of distinguishing them apart; that is, is capable of distinguishing them with ease and certainty, and without the possibility of error, in all circumstances in which they are fairly visible. We want to know whether the impressions made upon his retina by the two colours are so utterly unlike that there is no possibility of their ever being confounded.

For the attainment of this object, when we come to practical considerations, the worst possible test is one which is employed on many railways, by which the candidate is made to look at the actual signals as they would be presented to him in working, and is called upon to say which is red and which is green, or it may be, which means "stop," and which means "go-ahead." Such a test is worse than useless, because, for the reasons already given, the red lamp is not invisible to the red-blind, and the green lamp is not invisible to the green-blind. Each is seen as a light of small luminosity by virtue of the rays other than red or green which it transmits. Every colour-blind candidate would probably know, to start with, that what people called red, or what they called green, was to his perception a light of feeble luminosity, a faint or dull light instead of a bright one, and he would therefore guess that any dull light was of that particular colour which would naturally appear dull to his consciousness. Even without this help, there would be an even chance of a correct guess the first time, and such a guess would keep him right all through the trial, because the two lights would look different. What is wanted in testing is to eliminate at once the even chance, and the apparent difference of luminosity. Suppose a man is green-blind, and guesses correctly that the first light shown to him, a dim one, is green, he will, of course, feel sure that any brighter one is red. But if he is driving an engine at speed, and he is suddenly confronted by a red signal which, either from a defective lamp or from some atmospheric condition, does not seem to him to be bright, he will take it for green and will rush into the danger which he ought to avoid. All methods of primary testing by actual signals, or by any imitations of them, are vitiated by the circumstance that the colours employed are not sufficiently numerous to eliminate accidental correctness, and that they do not look precisely alike even to the colour-blind, when seen in successive minutes and in similar circumstances of atmosphere and of illumination. The colour-blind person, although not seeing any difference in colour on which he can rely, does see a difference in luminosity, and his weakness depends upon the fact that this difference is not sufficiently characteristic to be at all times trustworthy. For accurate testing it is not enough to see that a candidate, on a given occasion, does not fall into a mistake between two colours, but it is necessary to see that he cannot fall into one. The latter condition will only be fulfilled if his optic nerves possess the natural power of vibrating in response to each of the three primary colours of the spectrum, and, by natural consequence, in response also to their innumerable derivatives.

It was to accomplish this object that Professor Holmgren devised his famous test with coloured wools; and, as the object of this is to ascertain whether a person sees colours correctly, not to ascertain whether he names them correctly, the element of naming is carefully kept out of account. If we are once certain that a person can see the difference between red and green, there cannot be the slightest difficulty in teaching him the right name of each, even supposing that he did not know it before; but the knowledge of the names is absolutely useless as long as there exists any liability to confuse the things. The correct value of Holmgren's test has been very clearly and concisely stated by my friend Mr. Frost, whose words on the subject and whose description of the test I will proceed to quote. He says:—

"The state of colour-vision cannot be measured by making the subject of the test name the colour of substances, for in the first place there may be normal colour sense, and yet from defective education the colour may be wrongly named. In the second place the naming of a colour correctly gives no clue as to the subjective sensation which it excites. A colour-blind person may see reds and greens as different shades of the same colour, but may have learnt that what seem to him to be rather sombre shades of this colour are called red by others, while the brighter tints are called green; he may therefore name the colours correctly, and even believe that he sees the true difference between them, and unless the trial is repeated several times, and with a variety of shades, detection may easily be escaped. In this way a colour blind guard or pilot may interpret correctly signals to which he has been accustomed; if, however, they are dimmed by rain or mist, or if, from the distance being unknown, he is unable to compare the intensity of a red and green light, he may mistake the one for the other.

"A test of colour vision should be independent of naming the colours; it should be sufficiently exhaustive to preclude the possibility of evasion by chance or guessing, and should be sufficiently rapid to permit of large numbers of persons being examined in as short a space of time as possible; these requirements are fulfilled by Holmgren's coloured wools.

"The test consists of three parts; the first enables us to discover the existence of defective colour.vision, the second to detect its nature, while the third is merely confirmatory.

"In the first stage the examinee is given a test colour, a skein of a rather pale green, a grass-green much diluted, and there are spread out upon a white cloth, in a good light, a number of other skeins, consisting of all shades of green, as well as greys, drabs, pinks, and yellows, all considerably diluted with white; the examinee is then told to pick out from the heap those skeins which appear to him to be of the same colour as the one held by him, but without regard to differences of shades. If he chooses all the greens and no other colours, he has normal colour-vision; if this is defective, he will choose one or more of the 'confusion colours,' and he must be put through the second test."

"In this the test colour is a dilute purple or rose colour; as it is composed of red and violet, the red-blind matches it with blue and violet. For the green-blind a combination of red and violet produces grey, and green has a similar effect; hence he chooses these confusion colours. If the examinee fails in the first test, but succeeds in the second, he has a weak colour sense, but is not totally blind to one of the fundamental colours."

"In the third test a bright red, such as is used in signal flags on railways, is the test colour; the red-blind matches it with dark green and dark brown, the green-blind with brighter shades of these colours."

It will be observed that, in the foregoing description, the test is only to be applied in a "good light," or, as I should prefer to put it, only in full daylight without direct sunshine, as at a window with a north aspect; and that the skeins to be selected from are to be spread out upon a white cloth. Not one word is to be said as to the names of colours; and the only point to be determined is whether the examinee can see with certainty, or is more or less doubtful about, differences which to normal eyes are of the most conspicuous character, leaving absolutely no possibility for mistake between them. If, as between light green and light drab, the railway or marine candidate hesitates for a single moment, or makes any attempt even to compare them, he is not to be trusted to distinguish colours in all the varied circumstances in which they are liable to be brought before him in the course of duty. If he selects rapidly, and makes no mistakes, it is not conceivable that he should make them in any circumstances. Green and red will be to him distinct sensations, which it would be no more possible for him to confuse than it would be possible to confuse the taste of salt with that of sugar. In other words, he has a correct colour-sense, and it would be simply impossible for him to fall into any error on the question. If any colours other than greens are selected by the examinee, he is next given a shade of light purple to take as a standard in a similar way, and the nature of the errors which he makes in finding matches for this will show whether his colour-blindness is for red or for green. Although violet blindness exists, it is so rare, and so unimportant as regards industries, that it may be neglected. A third test of the nature of the colour blindness is furnished by endeavours to match a red skein, but this is only confirmatory of the results previously obtained.

Holmgren's test, carried out in rigid conformity to his instructions, has now been applied by skilled observers to young and adult males in almost every civilised country; and Dr. Joy Jeffries, in the last edition of his work upon the subject, tabulates the results of the examinations of 175,127 persons, conducted in the manner indicated. Among this number the per-centage of those with colour-blindness amounted to 3·95, and it is hence a fair conclusion that any method of examination which gives a per-centage differing from this in any marked degree must be vitiated by some error, either in its own nature or in the method of carrying it into effect.

The methods pursued on the English and Scottish lines of railway, and also by the Board of Trade, have, as far as I am acquainted with them, one feature in common, which is that they are all wrong, the direct offspring, in almost every instance, of a degree of ignorance and presumption the very existence of which would be incredible, if the proofs of it were not brought daily under our observation. Even where the use of Holmgren's method is professed, the rules laid down by Holmgren for conducting it are, as a rule, utterly ignored, and the results obtained are as utterly misleading. The test should be used in exact conformity with his very detailed and precise instructions, or it should not be used at all.

When properly applied, Holmgren's test may reveal one of several conditions. Normal colour sense is to be expected from 96 per cent. of the examinees, and among the rest there will be found complete red-blindness, complete green-blindness. incomplete red or green blindness, and a condition which may be described as a feeble colour-sense. All these can be distinguished apart with certainty, and they have been found in a sufficient number of instances to warrant the conclusion that the incomplete forms of colour-blindness vary in degree, and pass into normal colour sense by imperceptible gradations. It therefore becomes necessary, just as in the case of defective form vision, to possess some means of measuring the defect of colour sense, and of deciding whether or not it is sufficient to exclude the subject of it from the occupation in which it is his desire to engage. Considering that defective colour-sense affects only four per cent. of males, to whom many other occupations are open, I do not myself recognise any hardship in excluding the whole of them from the railway or marine services; and I would not, in either, accept a man who even for a moment hesitated whether or not to place a drab as a match for a green. The question, however, is one for employers to decide, more especially when it refers to retaining or dismissing a man already in the service; and hence various means have been devised of measuring the degree of colour defect, and of expressing it by a fraction. as is done with form vision. In order to effect this, Professor Holmgren has employed an arrangement by which a shadow is illuminated by coloured lights, and Professor Donders has employed small discs of colour, measuring the distances at which they are recognised, and also a lantern, fitted with interchangeable coloured glasses and with a revolving disc perforated with apertures of different diameters, the very contrivance, in short, which Mr. St. Clair Buxton has professed to invent within the last few months, and which was most fully described in Graefe's "Archiv für Ophthalmologie" thirteen years ago, before the most recent inventor of it became a member of the medical profession. Perhaps the best form of this contrivance is that which has been long in use on the Belgian State Railways. It consists of a lantern, before which glass of any desired colour can be placed; while in front of the glass there is a metal screen, with a central opening filled by what is called an iris diaphragm; that is, a mechanical arrangement by which the size of the aperture can be diminished or increased at will, with very slight departure from its circular outline. The examinee is placed opposite the lantern, and is directed to look towards it, and to call out "Stop" or "Go" as soon as he recognises a signal to justify either. The coloured glass being in position, the iris diaphragm is opened to such an extent as to represent a signal lamp at the farthest distance at which it would be visible. If the examinee is silent, the opening of the diaphragm is enlarged at such a rate as to represent the steadily-increasing visibility of a signal towards which an engine was running at the rate of thirty miles an hour. As soon as the examinee speaks, the enlargement is stopped, and the magnitude of the opening affords a precise measure of the acuteness of his colour-sense. Such contrivances as these, as all who are conversant with the subject have pointed out, are of no value, or at least are unnecessarily troublesome and cumbrous, for original testing, and are only useful in the conduct of the secondary examinations which may sometimes be required in order to prevent the possibility of injustice.

The outcry which has recently been made in certain journals which profess to have the interests of railway men at heart, has been a mere reproduction of the similar outcry, already mentioned, which arose some few years ago in the United States, and which was there speedily silenced by the influence and by the demonstrations of men of science, among whom the chief place must be given to Dr. Joy Jeffries, of Boston, who has himself carried out more than 34,000 examinations, and who has been mainly instrumental in rendering such examinations, properly conducted, obligatory in many, if not in all, of the States of the Union. The chief characteristic of the outcry, as we have lately heard it, is that those by whom it was conducted appear to have been illuminated, as regards the principles at issue, solely by the light of nature, and to have been absolutely ignorant alike of optics, of physiology, of previous research, of the weight which should attach to those by whom this research has been conducted, and sometimes of the meanings of the words they have employed. It is perhaps not surprising that Mr. Clement Stretton, who, I understand, is an engineer, should believe Professor Holmgren to be a German, or should entirely misdescribe his test, or should say that the "highest scientific authorities" (who are they?) differ as to its proper application; but it is melancholy, and to me humiliating, to find members of my own profession lending their support to all this utter nonsense. I read somewhere, and have vainly endeavoured to find again, a denunciation of the "fallacies of the Young-Helmholtz theory." I believe the writer of this delightful sentence had never even heard of Thomas Young, and that he had before his consciousness the idea of Helmholtz junior. Professor Helmholtz is probably the greatest of living physicists, and much of his life has been devoted to the study of the phenomena of light and colour, with the result that he thought the views of Young might be susceptible of some modification. But what shall I say of Young, the greatest philosopher (if we perhaps except Newton, one of whose only two important errors he corrected) that the world has ever produced, and, moreover, the philosopher who laid the foundation of all we know about either light or colour, by the establishment of the undulatory theory? Perhaps I may best do justice to his memory by quotations. Tyndall says of him:—"In the year 1773 was born, at Milverton, in Somersetshire, one of the most remarkable men that England ever produced. He was educated for the profession of a physician, but was too strong to be tied down to professional routine." I am proud to interpolate that he was physician to St. George's Hospital. "He devoted himself to the study of natural philosophy, and became, in all its departments, a master. He was also a master of letters. Languages, ancient and modern, were housed within his brain; and, to quote the words of his epitaph, 'he first penetrated the obscurity which had veiled for ages the hieroglyphics of Egypt.' It fell to the lot of this man to discover facts in optics which Newton's theory was incompetent to explain, and his mind roamed in search of a sufficient theory. He had made himself acquainted with all the phenomena of wave-motion, with all the phenomena of sound, working successfully in this domain as an original discoverer. Thus informed and disciplined, he was prepared to detect any resemblance which might reveal itself between the phenomena of light and those of wave-motion. Such resemblance he did detect, and, spurred on by the discovery, he pursued his speculations and his experiments, until he finally succeeded in placing on an immovable basis the undulatory theory of light."

Helmholtz himself, whom Tyndall describes as being of "kindred genius" to Young, thus speaks of him:—"His was one of the most profound minds that the world has ever seen, but he had the misfortune to be too much in advance of his age. He excited the wonder of his contemporaries, who, however, were unable to follow him to the heights at which his daring intellect was accustomed to soar. His most important ideas lay, therefore, buried and forgotten in the folios of the Royal Society, until a new generation gradually and painfully made the same discoveries, and proved the exactness of his assertions and the truth of his demonstrations."

One word may perhaps be given to Mr. Stretton's "German," Holmgren, the illustrious Professor at Upsala, to whom is due the great credit of having first strongly directed attention to the frequency and importance of colour-blindness, and whose numerous writings upon the question show that he has for many years made it a subject of laborious research in every possible manner, with tests of every description, with every experiment which ingenuity could devise or skill could execute. There is no possible use of the spectrum, of coloured glasses, or of coloured objects of every kind which Holmgren has not exhausted, and those who have not made acquaintance with his works will act most discreetly if they keep silence on the matter. It is too ludicrous to hear the doctrines of Young and Helmholtz, and the enormous practical experience guided by the encyclopædic knowledge of Holmgren, set at nought by two or three gentlemen of an age at which modesty is an adornment, whose acquaintance with the subject is derived from having made a score of people look through bits of coloured glass at a light, and who are capable of writing about "the fallacies of a theory." Perhaps I may illustrate the value of their opinions on two points, not having time to deal with more. One of them thinks his procedure likely to be specially valuable in cases of central scotoma for colour, a condition which he says exists; that is, a state in which there is colour blindness in the centre of the field of vision, and right colour sense over a ring around this centre. Over the other parts of the field, colour blindness is a normal condition. Now, as far as I am aware, and I have been surgeon to an eye hospital for more than thirty years, there is no such thing as central scotoma for colour except as a consequence of disease which produces also imperfection of vision for form; and the latter alone, without deficiency of colour sense, would constitute a sufficient disqualification. Another of our new lights professes to find, in a book mainly written by Mr. Juler, the assertion that "all colours if sufficiently illuminated appear white," and on this he suggests that fatigue of the retina would be likely to produce the same effect. Now, fatigue of the retina diminishes its sensitiveness, and would, therefore, assimilate a strong light to a weak one. In addition to this, our mentor does not appear to have read the whole of the chapter to which he refers, or he would see that, although appearing in Mr. Juler's book, it was written by Mr. Frost, to whom he ought to have given credit for it. Moreover, the passage referred to does not bear the interpretation put upon it, and could not mislead anyone who possessed even a smattering of physical optics. It refers, perhaps something less clearly than would have been possible, to the fact that the light reflected from the absolute surface of a coloured body is white, that only being coloured which has penetrated a little way into the substance, and has then been reflected from molecules beneath the surface. Hence, if the observer is so placed as to receive chiefly the rays reflected from the absolute surface, a coloured body may appear white. The question is not one of sensation, but of the character of the light which the eye actually receives, and it does not afford a shadow of support to the utterly absurd conclusion which has been attempted to be founded on it.

I am compelled by time to draw to a conclusion. It would be impossible to do justice to the subject except in a series of lectures, with an abundance of experiments; and no one can be more conscious than I am of how much I have been compelled to leave unsaid. I will make only a brief reference to the complaint that railway men are tested capriciously, concerning which I would say that such a course, if it be pursued, is clearly wrong. A candidate for employment should be tested, both for form and for colour-vision, before he is engaged; and he should be tested for both by an expert, according to the dictates of true science, as distinguished from sham science on the one hand, and from the ignorant presumption of the inventors of so-called practical methods on the other. After any accident, or any severe illness, he should be tested for form-vision again, and he should also be tested again, if he were originally what is called hypermetropic, that is, if his eyes were flat, at about forty or forty-five years of age. The test for colour-vision need not be repeated, because if this faculty should be affected by disease or injury form-vision would also be affected, and in a sufficient degree to disqualify the person. Against a condition in which form and colour-vision may both gradually fail, as a consequence of deep-seated disease of the nervous system, no safety is practically attainable; but the risk incurred in this direction is inconsiderable, because such disease would soon declare itself by other symptoms. I will only add that any one who wishes to understand the subject will be greatly helped by a careful study of the work of Dr. Joy Jeffries, of Boston, United States, on "Colour Blindness, its Dangers and Detection." If those who have taken part in the recent controversy had only mastered even as much of the question as is given in this book, there would have been a great saving of fruitless inkshed, as well as of time which might have been better employed.

DISCUSSION.

The CHAIRMAN said he was glad that this important subject had been brought forward in that Society, and he hoped what Mr. Carter had said would be the means of altering those systems of testing which he had shown to be so defective. He was sorry to hear that he condemned the system in use in the army, as well as on railways and in other employments.

Mr. W. R. BICKERTON said—This Society and the public are much indebted to Mr. Brudenell Carter for having brought forward this subject at this particular time, and I venture to say that his paper will mark an epoch in the controversy, which has continued since the year 1855, as to the relation of defective sight in our railway officials and in the mercantile marine: and when at last we can step into a railway carriage or a sea berth with the positive knowledge that we run no risk of destruction through the employment of colour-blind or otherwise defective-sighted officers, to none shall we owe a greater debt of gratitude than to Mr. Carter. Nothing has been more extraordinary than the apathy of those in authority to this special subject, and it is only now, when the public are beginning to learn that hundreds of lives and property to an enormous extent, are absolutely dependent upon the perfect far-sight and colour-sight of a look-out or officer on the bridge, that the Board of Trade are awaking from their long sleep of indifference. When the public become aware of the dangers which the travelling portion—particularly the sea-travelling portion—of the community run, they will speedily see that those in authority are made to do their duty; and now that the Press has taken up the matter, and Dr. Farquharson has, in the House of Commons, called attention to it, I have little fear but that efficient rules and regulations will ere long be made. What those tests should be you have heard, and I have not one word to add to what Mr. Carter has so clearly laid before you. To detect colour-blindness, there is, in my opinion—and I have had ten years' experience in this matter, and have myself tested upwards of 10,000 people—but one test trustworthy, and that is the wool test of Professor Holmgren; it is safe, simple, and reliable; it is as easily applied to the uneducated as to the educated, to the foreigner as to the Englishman; and this is of great importance, as many of our sailors are foreigners. I know of the case of a Welsh sailor who because he as often called blue green, and green blue was rejected as colour-blind. Now this was a mistake a real colour-blind would not make, and on making inquiry, I found that the Welsh word "glas" is as often used to describe the colour blue as green. All tests for the detection of colour-blindness, which require the naming of colours, are bad, and must, sooner or later, lead to wrong conclusions, and for this reason. It is quite impossible to convey to another by words the impression made on our brain by colour. But I am not going to discuss theories. Mr. Carter has demolished by scientific proofs the platform of those gentlemen who, knowing nothing of either the theory or the practice of Holmgren's wool test, absolutely condemn it, and write about its uselessness with a fluency which we can only put down to profound ignorance; and of those who, not content with existing tests, must, in obedience to clamour, or in order to show their knowledge of the subject, institute new ones. Where are Mr. Carter's tests, or Dr. Brailey's tests, or Mr. Nettleship's tests, or, again, Dr. Joy Jeffries' tests? These gentlemen have worked at the subject for years, and yet are content to follow the scientific footsteps of Professors Helmholtz and Holmgren, and of the philosopher Young. I should like just to mention a few facts to you. Are you aware that in spite of it being well known that at least 3½ per cent. of the whole male population are colour-blind, and that 8 per cent. have marked impairment of vision from refractive errors, there is no official test whatever as to a sailor's eyesight; that man may be the subject of any of the various forms of eye disease, may have any degree of blindness, or may be so short-sighted as not to be able to see distinctly more than a few inches in front of his nose, and yet be at perfect liberty to be a sailor, and to become an officer, and that although there is a compulsory colour examination—a most inefficient one—there is no check to a colour-blind man being a sailor or to his remaining so to his life's end. We cannot take up a single paper without reading of shipping casualties, and every now and then an appalling disaster, such as the loss of the *Ville du Havre* with its hundreds of lives, of the *Douro* collision with its death roll, and coming down more recently to the collision last February, 1889, off Beachy Head; with the total disappearance in less minutes than it takes me to relate of the s.s. *Nereid* and s. *Killochar*, brings forth in the Press some such remark as "all inquiries respecting the cause of the disaster lead to the same conclusion that it was due to one of those astounding errors of judgment on the part of one or other of the navigators which seem to defy all reasonable excuse." Read in the light I now suggest—viz., colour-blindness of the officer on watch—and the cause is as clear as daylight. And knowing these facts, why should there be any surprise when two vessels are rammed at each other, and both go to the bottom. Is it not a most natural thing to happen, and if there is room for wonder, should it not rather be that such occurrences do not occur oftener. I should not be surprised if I were told that the officer on board the *Nereid* were colour-blind. The explanation would then be that he took a green light for a red one and acted accordingly. That such a thing is possible the cases I will now relate will show you, and they will also show you how insufficient is the Board of Trade colour test—which test is the so-called practical one, the lantern test—which some friends of the railway men wish to see introduced. In conclusion, I would only say that if every person who goes to sea, before taking his berth, writes to ask the company whether their officers and men are tested as to their sight and colour vision, it would be the means of doing a great deal of good. Mr. Bickerton quoted the following cases:—Captain Coburn wrote to the *Mercantile Marine Service Reporter* that shortly after his steamer left Gibraltar he went on the bridge when the third officer was in charge of the ship. He saw a green light about two points on the starboard bow, and to his surprise the third officer cried out to the man at the wheel, "port." The captain immediately countermanded the order, and they passed the other steamer safely about half a mile apart. When he questioned the third officer as to his action he said that the light he first saw was red. The captain added:—"I tried him repeatedly after this, and although he sometimes gave me a correct description of the colour of the light, he was often incorrect, and it was evidently all guesswork." A letter from Mr. John

Smith, printed in the leading London shipping journals, contained a description of the case of the writer who had the certificate of the Board of Trade, but was unable to pass the colour examination of a private owner. He urged on the Board of Trade the necessity for a far more perfect means of testing sight.

Mr. W. A. Frost said he would only say a word or two on the practical part of the question, because many railway men were advocating a mode of testing which he would point out was quite unpractical. There was no word in the language which was used in so many different senses, and he had heard it said that a practical man was one who went on practising the errors of his predecessors; in that sense, no doubt, it was practical, but in no other. In a letter which Mr. Stretton wrote to the *Times*, he said the man ought to be taken on the line and tested at 100, 500, and 1,000 yards, and for any other practical distance, by day, at night, between daylight and dusk, in fine weather and in wet weather. They all knew that railway companies were very powerful, but they could not command the weather, so that possibly a man might have to wait three or four weeks, or even longer, before the test could be completed, and even under the most favourable circumstances it could not be finished under 48 hours. Some people looked on what they called the scientific test as a kind of toy to amuse the examiner; but surely a scientific test was one which, undertaken under certain known conditions, would enable one to say with absolute certainty what would take place under all other conditions; it was in that alone that the scientific character of the test consisted. He had no hesitation in saying that in his opinion the Holmgren test as it stood, or with some slight modification, was by far the best; but the test alone was not sufficient. There must be stringent rules laid down as to the manner in which it should be used. On some lines it was used in a manner which was very unfair to the men, some of whom had been disqualified who were not colour-blind at all. Some days ago he had a letter enclosing two pieces of wool, one a yellowish green and the other a pink, and he was informed that a man had been disqualified for calling one yellow and the other red. He then went to a Berlin wool shop, and got some instruction in the naming of wools, went back again, and passed. Now, colour-blindness was absolutely incurable, and anyone whose vision was really defective in this respect could never pass a proper test with any amount of instruction. Now, in the case of the Board of Trade, the reports gave all particulars of the men who were rejected, with their names, and he found that they were allowed to be examined as often as they pleased, and after three or four rejections, men would pass as having normal vision. It was evident, therefore, either that they were wrongly rejected at first or passed wrongly afterwards. A test must be very efficient indeed where a man of fair intelligence and good powers of observation could not manage to pass if he were allowed to go up any number of times; but as colour-blindness was incurable—and there were absolute tests for it—there could be no object in allowing a man to be re-examined any number of times. At the same time it was only fair that a man should have a court of appeal. He should first be examined by the local authorities, who should be unconnected with the line, and if rejected he should have the power of appeals to some central Board, whose decision should be final. Then, again, those who passed should be re-examined after a certain number of years. It would be practically very difficult to have an examination annually, though that ought to be done; but it was very important that a man should be re-examined when he reached a certain age—say about forty—when some of the muscles of the eye began to get defective, and other changes took place in the system.

Mr. H. Trueman Wood regretted that there were no railway engineers present to take part in the discussion. Mr. Carter had been asked to read the paper because the Council were assured that no one was so capable of putting in a clear and lucid form those facts which the gentlemen he referred to ought all of them to know, but which many of them did not know. He thought perhaps a misleading idea must be obtained from one expression used, referring to the three primary colours in the spectrum. The phrase should be, three primary colour sensations, for he did not think there could be any authority for believing that there were abrupt transitions in the spectrum, which was a uniform gradient composed of an infinite number of colours, which were all entirely homogeneous; the yellow was absolutely homogeneous and so was the red or green; you could disperse the rays as far as you pleased, but still they retained the same colour — you could not resolve them. Colour, of course, had no objective existence; it was purely subjective. In the retina were nerves which were sensitive to red, or green, or blue, the intermediate colours being perceived because the nerves were also fairly sensitive to the adjacent parts of the spectrum; for instance, yellow light was assumed to affect slightly both the red sensitive and the green sensitive nerve fibres. With regard to the question of astigmatism, he should like to ask whether it would really prevent a signalman seeing such an object as the arm of a signal? He had some practical knowledge of that visual defect, and though he could not see with any distinctness fine horizontal lines, he had no difficulty in observing a broad horizontal bar any more than a vertical one. He had often heard people who did not know much about it express wonder that blue was not used for signals, or purple, instead of always red and green, but the reason was the extremely feeble luminosity of the blue and violet rays. Some time ago he made a series of experiments, with the idea of discovering the best light for a photographic dark room, which would enable one to see fairly well without affecting the photographic plate. Of course, any light affected a sensitive plate in some degree; if you exposed it sufficiently long to red light it produced the same effect as white light. He was surprised to find how little the absence of the blue rays affected the luminosity of the spectrum, and how little one could see to work with a fairly bright blue light. Mr. Bickerton had said a great deal about tests for seamen, but he could not think that in the present dearth of seamen it would be wise to still further check the supply in any way. Even in the unlikely event of the look-out man being unable to distinguish between the port and starboard lights, it would not do much harm, as he would be set right by the officer in charge of the deck. If the apparatus which was described as being employed in Belgium came into use in this country, he would suggest that a much more accurate mode of measuring the amount of light passing than the iris diaphragm would be the ingenious rotating disc which Captain Abney used for an absolutely identical purpose. It had a radial sector which could be adjusted so as to allow any amount of light to pass, and as it rotated very rapidly, it diminished the light passing through it in a degree which could be easily ascertained by measuring the angle of the opening.

Mr. **Oliver J. Williams** agreed with Mr. Wood as to the undesirability of throwing difficulties in the way of sailors. Besides the look-out man there were the men on watch, as well as the officer in charge; there were generally two men at the helm, and always one, so that there were always three men on deck; therefore the danger at sea was not so great as might be imagined. He did think, however, that the Trinity Board should have its pilots examined more carefully, and that all officers before getting certificates should be very carefully examined for colour. He knew of many cases in the Court of Admiralty in which ships had gone ashore in consequence of mistaking the colour or description of light. It was a very common thing in the pleadings in that Court to say that, in consequence of a snow storm or fog, they could not distinguish the lights, but no eye-test would probably get rid of that difficulty.

Dr. **Edridge-Green** said he had listened to Mr. Carter's paper with great interest, but there were many points on which he disagreed with him. He was the author of the article on the Young-Helmholtz theory referred to, and he would say that if anything said by a great man were never to be questioned, there would be an end of all accurate investigation. He had devoted an enormous amount of time to this subject, and he would mention one thing which it seemed to him could not possibly be explained by the Young-Helmholtz theory. It was a well-known act that many colour-blind people were able to see shade; a red-blind man, if his spectrum were the normal length, would be able to see shade precisely the same as a normal sighted person did. On the diagram the red-blind whom Mr. Bickerton spoke of would be represented by the two curves on the right, and the left curve would be absent. According to the Young-Helmholtz theory, the case of red blindness was one in which the curve was entirely gone, and therefore the red would be scarcely seen at all, but the green would be almost the same as with normal sight. Therefore, if that man had to to match a green to a red so as to pick out twin colours, he would pick out a bright red and put it with a very dark green. But they did nothing of the sort. He had sixty pictures painted by colour-blind people, and those who had spectra of normal length matched the shades in exactly the same way. He did not see how that could be explained by any theory which attributed colour-blindness to something being taken away from the retina. He had come to the conclusion, after the most careful consideration, that the Holmgren test was very inefficient for sailors or railway *employés*, for the following reasons. He had examined 104 cases of colour-blindness, in some cases spending every afternoon for about three weeks in testing them by every possible method, and he found that those who were completely colour-blind, red and green, could be instructed so as to pass the Holmgren test. He had there several pictures painted by a man who was completely red and green blind, and by telling him how to keep to the colour, he passed the test easily and very rapidly. He should be glad to send this man to Mr. Carter and let him test him himself. Another objection to this test was that normal-sighted persons, if uneducated, were very apt to pay more attention to the shades than to the colours, and so pick out the confusion colours, and so they might be rejected, though with a little instruction they would distinguish the colours perfectly. That was the great objection, that it introduced another factor —shade, which sometimes misled uneducated persons. What he called 3, 4, or 5-unit persons, if educated, would easily get through the test. The Young-Helmholtz theory also failed to explain the shortening of the spectrum, which might extend right up to the orange. Another objection to the Holmgren test was that it would not detect those cases of the shortening of the red end of the spectrum, which were the most dangerous cases, because such men could not see a red light at all. A man came to him and said he had something wrong with his sight, as he mistook greys and yellows. He first examined him by the Holmgren method, and he said he could always match greens perfectly well, but it was the reds, and greys, and yellows he found a difficulty with. He would have been a most dangerous man to have on a railway or at sea, but he got through the test perfectly well. When he told him to pick out all the greens, the only mistake he made was in picking out two or three blues. It had been said that colour-blind persons did not mistake blues and greens; but that was an error. Mr. Wilson, who had written an excellent book on the subject, far superior to that of Joy Jeffries, said there were three varieties of colour-blindness exhibited in those who mistook blue and green, brown and green, and red and green. A 4-unit person would confuse blue and green, a 3-unit brown and green, and a 2-unit red and green. He had never said that a person with central scotoma was free from other disease of the eye, but he must say that the Board of Trade had no test for visional vacuity, and that with the Holmgren test, those having visional vacuity would get through. He had examined one and found he passed very well; but on examining him with small pieces of colour he made great mistakes. With his lantern test he expected a man to know four colours, red, yellow, green, and blue. The advantage of this test was that it changed the colour, by the aid of neutral glasses to the colour-blind, without altering them to the normal-sighted. He had two red glasses, one impermeable to green rays, and the other not. A person having a shortened spectrum would see only green rays, where a normal-sighted person would see only a bright red; and there would be no possibility of his escaping detection.

Mr. H. MURFETT asked if there was any return of accidents on engines through the drivers being colour-blind; he did not think there were many. There could be no more practical tests than the ordinary work of an engine driver. They had three practical lights to go by; the red, the running light, or green, and what they called the shunting light, the white or yellow. The lights were changed as quick as lightning, and if you were not very careful when shunting you would find yourself off the road. That was a practical test of the quickness of engine drivers in approaching the points in a yard. There were many other places which they had to approach with the same care coming from Moorgate-street to King's-cross, at the junctions where the trains passed and repassed in quick succession, two or three in five minutes. If a driver running to the City did not practically distinguish the lights very accurately there would soon be a disaster, and he thought a practical test of that kind was quite equal to any devised by gentlemen who lived amongst colours.

Mr. BOND (surgeon to the Great Western Railway) said that he came at the express desire of the managers of the Great Western Railway. Some time ago he was asked to give them information as to the best means of colour-testing, when he said he was unable to tell them, but he took the opportunity of learning all about it, and had read everything which had been written upon it. He had not yet made his report as to what he considered the best way of testing, and he came there for instruction, but as far as he had been able to gather from reading scientific works, and all that had been recently written, his opinion coincided with Mr. Carter, that the Holmgren test, properly applied, would meet the case. There was a great difference between men who had to see lights at sea and engine drivers. Lights at sea flashed upon a man at all sorts of moments when he did not expect them, and in all sorts of emergencies; whereas an engine driver was taken over the road many times before he took charge of an engine. He knew the exact position of every light, and the sort of light he was liable to meet with, so that railway travellers did not run the risk of confounding lights as at sea, and practically it worked out that few mistakes were made by engine drivers. Such was the information conveyed to him by responsible managers of railway companies. The Great Western Railway, he might say, were most anxious that everything that science could suggest should be done to guard against mistakes of this kind.

The CHAIRMAN then proposed a vote of thanks to Mr. Carter for the great trouble he had taken in preparing his very able paper, which was carried unanimously.

Mr. BRUDENELL CARTER, in reply, said he had been much interested in the evidence brought forward by Mr. Bickerton, who had had a great deal of experience in this question with the pilots on the Mersey. He was very glad to meet Dr. Edridge-Green, whose views were well known to him. But he would remind him that it was part of the direction given for the use of the Holmgren test that the examinee was to totally neglect shade, to attend solely to colour. That was one of the points on which, if the instructions were neglected, results which were not intended might very well be obtained. Dr. Edridge-Green had called upon him to explain certain matters with regard to the Young-Helmholtz theory. He would only say, in the first place, that the facts were not sufficiently before him to venture at that late hour to attempt an explanation, but he would suggest to him that if he thought the views of Young and Helmholtz in connection with colour-sense were in any respect erroneous, he should lay before the Royal Society evidence in favour of his opinion, and if he could succeed in showing that they were erroneous, the Royal Society would welcome such a contribution, and would place his name on the illustrious roll on which Young and Helmholtz were already inscribed. That would be a better course than writing to the papers. With regard to a man being taught to pass the Holmgren test, he was obliged to say there, as he had said to Dr. Edridge-Green privately, that he thought there was some error in the matter. There was an officer in the last century, a great duellist and fire-eater, who was very fond of bragging of his own exploits, and at a certain dinner he gave an account of an extraordinary leap which he had taken on horseback. A cautious solicitor who was in the company, and who was afraid to contradict him, said it was the most extraordinary leap he had ever heard of, and supposed that if even the colonel himself had not seen it, he would hardly believe it. "No," said the colonel, "I certainly should not." At which the solicitor replied, that was exactly his case; not having seen he could not believe. That was precisely his opinion on this matter. He had no doubt that Dr. Edridge-Green was in his own mind justified with the statement he had made ; but he felt almost certain that he must have been in some way misled. He could only say that if the Doctor would send these partially colour-blind gentlemen to him, he would examine them and communicate the results. He would say to Mr. Murfett that, in the first place, it was unnecessary to say how much they all felt and acknowledged the debt due to the skill, caution, and courage of the class to which he belonged; but among the males of this country only 4 per cent. had a defective colour sense; therefore there was not room for many of them amongst the ranks of the engine drivers. It could only occur in a small number of instances; but Mr. Murfett would agree that if a man were unable to see with absolute certainty the difference between a green and red light, he would be a dangerous man on the footplate of an engine. They had certainly seen some railway accidents and collisions which were clearly traced to colour-blindness. With regard to marine accidents, there was a very terrible accident on one of the New York rivers some years ago, and Dr. Joy Jeffries with great difficulty traced out the pilot of the boat that came into collision with the other and caused the accident, and found him to be colour-blind. Until that was done, that collision had been looked upon as quite inexplicable.

Correspondence.

THE publication of the correspondence relating to Sir Robert Rawlinson's paper, on the "Sewage and Sewerage of London," is postponed until next week on account of want of space.

Obituary.

SIR ROBERT ANSTRUTHER DALYELL, K.C.I.E., C.S.I., LL.D.—Sir Robert Dalyell died suddenly at Edinburgh on Saturday, 18th inst. Sir Robert was born in 1831 and educated at Cheltenham and Haileybury College. He entered the Madras Civil Service in 1851, and in 1873 was made Chief Secretary to the Madras Government. In 1875-76 he was Chief Commissioner of Mysore, and in 1877 he was appointed a Member of the Council of the Secretary of State for India, of which he was Vice-President in 1883-84. He resigned in 1887, when he was created a K.C.I.E. He was elected a Member of the Society of Arts in 1885, and was a Member of the Royal Commission of the Colonial and Indian Exhibition of 1886.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

JANUARY 29.—GILBERT REDGRAVE, "The Utilisation of Blast-furnace Slag." Prof. W. C. ROBERTS-AUSTEN, F.R.S., will preside.

FEBRUARY 5.—ARTHUR PAGET, "High-speed Knitting and Weaving without Weft." W. ANDERSON, Vice-President of the Society, will preside.

FEBRUARY 12.— GEORGE FINDLAY, General Manager London and North-Western Railway, "Modern Improvements in Facilities for Railway Travelling."

FEBRUARY 19.—Prof. SILVANUS P. THOMPSON, D.Sc., "The Organisation of Secondary and Technical Education in London."

SIR DOUGLAS GALTON, K.C.B., D.C.L., F.R.S., Vice-President of the Society, "The Chemin de Fer Glissant, or Sliding Railway."

G. N. HOOPER, "Carriage Building and Street Traffic in England and France."

J. S. KELTIE, "Commercial Geography."

J. TRIPPLIN, "Recent Progress in British Watch and Clock Making."

ARTHUR MONTEFIORE, "The English in Florida."

Prof. R. MELDOLA, "Recent Progress in Photographic Chemistry."

FOREIGN AND COLONIAL SECTION.

Tuesday afternoons, at Five o'clock:—

FEBRUARY 18.—J. HENNIKER HEATON, M.P., "Ocean Penny Postage and Cheap Telegraph Communication between England and all Parts of the Empire and America."

APRIL 18.—SIR JOHN STOKES, K.C.B., "The Danube and its Trade."

A. LASENBY LIBERTY, "The Industrial Arts of Japan."

C. G. WARNFORD LOCK, "Gold Mining in Hungary."

INDIAN SECTION.

Friday afternoons, at Five o'clock:—

SIR J. THEODORE HOPE, K.C.S.I., "The Rationale of Indian Railways."

T. Talboys Wheeler, "Old Madras."

Applied Art Section.

Tuesday evenings, at Eight o'clock:—

January 28.—Edward C. Robins, F.S.A., "The Relation of the Fine Arts to the Applied Arts." Walter Crane will preside.

February 11.—W. R. Lethaby, "Cast Iron and its Treatment for Artistic Purposes."

March 4.—James Orrock, R.I., "The Claims of the British School of Painting to a thorough representation in the National Gallery."

[Pictures by illustrious English masters whose works are not included in the National Gallery will be exhibited by Mr. Orrock.]

April 15.—C. Purdon Clarke, C.I.E., "Modern Indian Art."

May 13.—Prof. W. C. Roberts-Austen, F.R.S., "The Use of Alloys in Art Metal-work."

Cantor Lectures.

Monday evenings, at Eight o'clock:—

Professor Silvanus P. Thompson, D.Sc., M.I.E.E., "The Electro-magnet." Four Lectures.

Lecture II.—January 27.—*Principle of the Magnetic Circuit.*—Experimental data. Predetermination of iron and copper for given traction. Heating of coils.

Lecture III.—February 3.—*Special Designs.*—Various forms and their uses. Electro-magnets for quickest action; for longest range; for maximum traction; for minimum weight; for alternate currents; for series work; for parallel work.

Lecture IV.—February 10.—*Electromagnetic Mechanism.*—Range of action of various forms of electro-magnets. Plunger and coil. Equalizers. Modes of preventing sparks.

MEETINGS FOR THE ENSUING WEEK.

Monday, Jan. 27...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Prof. Silvanus P. Thompson, "The Electro-magnet." (Lecture II.)

Scottish Society of Arts, George-street, Edinburgh, 8 p.m. 1. Mr. William Key, "The Control of Water Pressures in Mains and Services by Day and Night." 2. Mr. William Bruce, "Notes on Cement-testing and Cement Concrete."

Actuaries, The Quadrangle, King's College, W.C. 7 p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

Asiatic, 22, Albemarle-street, W., 4 p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Prof. A. W. Rücker, "Electrical Forces."

Tuesday, Jan. 28...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Applied Art Section.) Mr. Edward C. Robins, "The Relation of the Fine Arts to the Applied Arts."

Royal Institution, Albemarle-street, W., 3 p.m. Dr. G. J. Romanes, "Before and After Darwin.—The Post-Darwinian Period." (Lecture II.)

Medical and Chirurgical, 20, Hanover-square W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Discussion on Mr. George Fosbery Lyster's paper, "Recent Dock Extensions at Liverpool." 2. Mr. W. H. Wheeler, "Bars at the Mouths of Tidal Basins."

Anthropological, 3, Hanover-square, W., 8½ p.m. Annual General Meeting. Address by the President, Dr. John Beddoe.

Wednesday, Jan. 29...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. Gilbert Redgrave, "The Utilisation of Blast-furnace Slag."

Cymmrodorion, 27, Chancery-lane, W.C., 8 p.m. Prof. Dobbie, "Scientific Farming as applied to Wales."

Mechanical Engineers, 25, Great George-street, S.W., 7½ p.m. Annual General Meeting. 1. Mr. Thomas Urquhart, "The Compounding of Locomotives Burning Petroleum Refuse in Russia." 2. Mr. Michael Stephens, "The Burning of Colonial Coal in the Locomotives of the Cape Government Railways." 3. Mr. Kenneth S. Murray, "The Mechanical Appliances employed in the Manufacture and Storage of Oxygen."

Thursday, Jan. 30...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Mechanical Engineers, 25, Great George-street, S.W., 7½ p.m. Reading and Discussion of Papers continued.

London Institution, Finsbury-circus, E.C., 6 p.m. Mr. Walter Macfarren, "Mendelssohn and his 'Lieder ohne Worte.'"

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Mr. Emil Behnke, "Elocution" (with illustrations by Mr. Hermann Vezin, Miss Laura Johnson, and the Lecturer).

Royal Institution, Albemarle-street, W., 3 p.m. Mr. E. R. Mullins, "Sculpture in Relation to the Age."

Camera Club, Bedford-street, Strand, W.C., 8 p.m. Mr. T. R. Dallincyer, "Some Practical Deductions from the Law of Conjugato Foci."

Friday, Jan. 31.. United Service Inst., Whitehall-yard, S.W., 3 p.m. Major F. W. J. Barker, "Modern Gunpowder as a Propellent."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Sir Frederick Abel, "Smokeless Explosives."

Mechanical Engineers, 25, Great George-street, W.C., 8 p.m. Reading and Discussion of Papers continued.

Saturday, Feb. 1...Royal Institution, Albemarle-street, W., 3 p.m. Prof. Flower, "The Natural History of the Horse, and of its Extinct and Existing Allies."

Correction.—In the last number of the *Journal* (p. 157) the late Mr. Daniel Adamson's Christien name was incorrectly printed as David.

Journal of the Society of Arts.

No. 1,941. Vol. XXXVIII.

FRIDAY, JANUARY 31, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

The second lecture of the course on "The Electro-Magnet," was delivered by Professor SILVANUS P. THOMPSON, D Sc., on Monday evening, 27th inst., when he specially dealt with the principle of the magnetic circuit.

The lectures will be printed in the *Journal* during the summer recess.

POPULAR AFTERNOON LECTURES.

The Council have arranged for a course of popular lectures to be given by Professor VIVIAN LEWES, on the following Saturday afternoons at Three o'clock, March 8, 15, 22, 29. The subject will be "The Atmosphere."

The lectures will be of a popular and elementary character, and will be fully illustrated by experiments.

The regulations for admission will be the same as for the Cantor Lectures, each member having the privilege of admitting one friend.

UNION OF INSTITUTIONS.

The following institution has been received into union since the last announcement :—

Stockport Technical School, Stockport, Cheshire.

Proceedings of the Society.

APPLIED ART SECTION,

Tuesday, January 18, 1890: WALTER CRANE in the chair.

The paper read was—

THE RELATION OF THE FINE ARTS TO THE APPLIED ARTS.

By EDWARD C. ROBINS, F.R.I.B.A., F.S.A.

The relation of pure science to the applied sciences is perhaps the best analogy between the fine arts and the applied arts. The pursuit of truth for its own sake is the characteristic of men of science pure and simple. The application of scientific truth to the every-day requirements and industries of life is the utilisation of true principles of science for the development of the useful arts and the increased intelligence of manual labour and constructive design.

In like manner the pursuit of beauty for its own sake is the characteristic of artistic genius. The application of the true principles of beauty in art is essential to the full development of the applied arts, which primarily consist of a happy association of the fine and useful arts dedicated to noble purposes.

In the rage and race for the establishment of technical education, the popular cry ignores all abstract studies, and construes the phrase "applied art and science" to mean little more than a better sort of handicraft—the domination of the practical over the theoretical; whereas, on the contrary, it is in the application of pure science and fine art to handicrafts that the much-to-be-desired superiority is to be attained. It is the general intelligence of the workman that is to inspire his work, and make it the produce of educated enthusiasm.

The introduction of manual exercises and the use of tools in elementary schools is an admirable thing, but the substitution of mere handicraft for technical education in principles and methods, in middle-class schools, would be the inversion of the right order of procedure. The workshop is unquestionably the best arena for practical work. Technical education is, or ought to be, instruction in the principles of science and art, underlying and forming the basis of all mechanical contrivances and of all beautiful things. It would be fatal to the success of the new movement in favour of technical education if it were to be reduced to the mere teaching of a trade or handicraft. At Owens College, Manchester, at the Yorkshire College, Leeds, at the technical colleges of the City and Guilds of London Institute, and similar foundations, no such mistake is being made; but it is to be feared that in the projected polytechnics, as they are inappropriately called (for they bear no comparison with foreign institutions of that name), the principles may become subordinated to the practice, and the desire to compete numerically may lead to the development of quantity rather than quality, and the substitution of the lecture-room for the laboratory.

Be that as it may, I am concerned in this part of my paper to draw attention to the necessity of keeping in mind the fact that the workshop is the place for applying those principles of beauty in art which are not taught in the workshop, but may be taught in the technical school, and which are necessary to give the worker the intelligence required to enable him to profit by the opportunities which the workshop alone adequately supplies to the handicraftsman.

The infinite division of labour growing out of the multiplication of machinery will always tend to the production of much mechanical labour in which the intelligence of the workman counts for very little; and there will always be labourers enough to supply the demand for such assistance; but for the really skilled mechanic and art-worker there are abundant means and opportunities for the infusion of personal character and taste, and for the assertion of his individuality.

Too much, however, must not be expected of the ordinary workman, but much more should be demanded of higher class men, whose business it is to direct them—on whom devolve the origination of the *modus operandi*, and the responsibility of the design and execution of elaborate works of useful and ornamental art. It is the custom of the day to speak of technical education as if it were a matter which concerned the working classes alone, but there is no greater mistake than this, and the beneficial influence of technical education will never be fully realised until foremen, masters, and professional men are equally well cared for in this respect, and have equal opportunities for distinguishing themselves.

Ordinary elementary technical education is desirable for all classes of the community; but higher secondary scientific and artistic education, fitted for the higher range of intelligences represented by professional men, masters, teachers, or the prize-winners in the lower schools, is that kind of applied science and art teaching which is required to maintain the superiority of this country's manufactures over all foreign competitors. This cannot be too strongly insisted on.

The work of the City and Guilds of London Institute for the Advancement of Technical Education will always be a credit to its founders, because from its first inception this principle was acted upon in the most practical manner, as evidenced by the establishment, in the first place, of the Finsbury Technical College, and in the second place by the founding of the Central Institution at South Kensington, the former being intended for youths fresh from school, young men and apprentices, and artisans of every age and class, who could pass a preliminary examination sufficient to test their fitness to benefit by the two years course contemplated; and the latter for the continuation of the education of the students who passed in honours at the Finsbury College, and other similar institutions, and for the higher education required for professional men, manufacturers, and science and art teachers generally—in short, an English version of a foreign polytechnic school or college of applied science and art.

In connection with the first of these institutions an admirable school of applied art has been established under the able leadership of Mr. Brophy, in association with antique and life schools for both sexes.

A second art school has been established at Kennington, South London, under the guidance of Mr. Sparkes, in which life schools for drawing, painting, and modelling are provided; also antique architectural model and wood-engraving classes.

At the Central Institution no such art teaching has been commenced, although that was the first intention, and a portion of the building was set apart for the fine arts, which has since been devoted to science-teaching purposes, and no professors of the fine arts have as yet been appointed.

This branch, however, is never found wanting in foreign polytechnics, which are not considered complete without their art side—with its staff of professors of architecture and construction and painting and sculpture. The Professor of Architecture at Carlsruhe was the architect of the new Strasburg University, which has cost half a million of money. In this particular, therefore, the Central Institution in its present development cannot compare with foreign polytechnica, being almost exclusively devoted to the applied sciences; and my regret that this should be the case has had its influence in determining the subject of this paper.

During the delivery of Mr. Alan Cole's interesting paper on Irish Lace Industries last session, a striking example was given of the importance of maintaining a close alliance between the fine arts and the applied arts. The paper was illustrated by enlarged photographs of original laces, contrasting designs made before and after art lessons had been introduced into that country, and showing the waste of energy which had long been expended in bad designs wherein the workmanship was beautiful, but the value was deteriorated by reason of the lack of taste in the design, and the absence of fine art culture observable in its general arrangement and ornamental detail.

Regarded from a scientific point of view, the great metropolitan institutions of the City and Guilds of London Institute referred to are complementary the one to the other; and thus for the first time in the educational history of the country they supply the necessary aid to the full development of the science side of technical education, the teaching being not only abstract but experimental; not only of the lecture-room but of the laboratory, and beyond this original work is aimed at and accomplished by third-year students, constituting these institutions schools of research. This characteristic is not so fully appreciated as it should be, because it is not generally understood.

The higher scientific studies thus inaugurated will soon begin to be felt, and the importance of them to the country at large will manifest itself in the gradual provision of men fitted by education and experience to seize upon every incident that opens the way to new discoveries and new applications of science, thus contributing to the maintenance of our national preeminence in analytical and mechanical contrivance.

Science is not like a dead language; it is a living and growing thing in the hands of competent professors and students of its manifold mysteries. What we want most of all is to produce original thinkers and cunning manipulators to lead on the rest of the community, and to provide teachers as well as learners practically acquainted with the applications of the sciences to be taught.

Regarded, however, from a fine art point of view, this end has not been attained, but it must follow if we are to distance our competitors all round. Genius is chiefly "the power to take infinite pains," and though, as Burges remarked, "a good eye is the special gift of a good God," the training of the eye and hand, and patient observation of the beautiful in nature and art, is the most direct way of making genius available for the advancement of art, and for the cultivation of the natural taste of all.

Schools of high art are as needful as schools of science to the development of all that makes for success in the great competition with the world in which our race is engaged. Just as the principles of pure science are necessary to the existence of applied science in the useful arts, so the knowledge of the principles of beauty in the fine arts is essential to the production of superiority in the applied arts.

The exquisite proportion of perfect form and the superadded charm of harmonious colouring combine to produce beauty in design, and the true principles underlying each are not beyond acquisition, although it may still be true that "a poet is born, not made."

Drawing, painting, modelling, and other exercises for the hand and eye are means employed to realise the ideal of the artistic sense, and the cultivation of these methods of expression is within the province of the higher technical schools to provide. Leaves and flowers, fruitful fields and landscape, animal life, and the human form divine, supply the object lessons; and in the conventionalisation of natural forms to common uses by the artist, his designs, in his own work and in the hands of skilled art workmen, become applied art. This power to direct, control, and instruct subordinate art craftsmen, is the force we most lack and therefore most require to foster. National character we have, individuality is ours, the best of our work in every age proclaims our independent self-helpfulness; but the labourers are few and the rewards limited, from the absence of national patronage, while the prevailing public ignorance and consequent lack of appreciation has a deadening influence on native enthusiasm.

As I have elsewhere observed, what Coleridge said of a picture may be equally appositely remarked of all artistic work, "A picture," said he, "is the intermediate something between a thought and a thing." Now the "thought" and the "thing" stand respectively for the outer world of matter and the inner world of mind. The "thing" or object is received and taken from visible nature into the inner mind of the artist, and thence being elaborated and combined with his individual thought and feeling, comes forth a second time into actual existence under the new and created form of art. The primary, the raw material, is nature; the forming, however, is mind, and the ultimate product is art. Nature enters into the mind a fact, a reality, and issues forth a picture, a poem, an ideality. To the nature around him the artist adds his own nature—

> "And thus it is that native air,
> Mind informs with visions fair."

"Art of all kinds," said Mr. Sedding, in his able and eloquent paper, read at the Edinburgh Congress, on "Some Sources of Expression in Architecture," "comprehends the forms in which men of genius utter what is in them. Art is the speech of poetic minds, and a work of art acquires its poetic interest by the simple fact that the artist has pressed out of his imaginative self the master qualities of his mind and imparted these to his work. The thing speaks for the man and of the man. The dead, inanimate material that the artist handles—be it a lump of clay, a stretch of canvas, a heap of stones—is quickened into life, transfigured by the man's communication of his own spirit to the thing. It would seem then, that a work of art—poem, building, or painting—gains the singular gift of attractiveness from the personality of the man. The artist strikes the imagination of others by pressing into his work his own imaginative qualities."

"Before we can have art," says Mr. Walter Crane, "we must have sensibility to beauty, and before we can have either we must have conditions which favour its growth. We must have an atmosphere, since this quality of beauty is an outcome and efflorescence of delight in life under happy conditions."

Abstract ideas of beauty in art are represented in concrete form by architecture, painting, and sculpture, the harmonious blending of each with the other constituting the practice of the fine arts. The application of the true principles ot beauty involved in the practice of the fine arts to the common things of life is comprehended in the phrase, "Applied Art."

The fine art of architecture is the nursing mother of all the arts. The temples of Egypt, Greece, Rome, and of the Middle Ages are the embodiment of its spirit. The sacred fanes of every clime are centres round which do congregate every emotion of man's heart, every beautiful conception of his brain, every curious device and cunning artifice the work of his hands. Within the exquisite proportions of the stately cathedral resound the pealing organ and choral voices, amid the rich colours of precious stones, and painted walls and windows, and the ravishing monuments of the carver and sculptor's genius, all echoing the orator's lofty sentiments of moral and religious truth.

Contemporaneously with the temples of the world are the palaces of its kings, the public monuments of the State, the baronial halls of its nobles, and the homes of the people, each and all in various ways demanding the expression of their use, and affording opportunities for the exercise of artistic refinement in their design, the embodiment of the spirit of the fine arts in their conception, and the association of all the applied arts in their realisation.

Architecture as a fine art, and apart from its manifestation of constructive skill and scientific power, is the most impressive and enduring of all the arts. The imagination of the observer is carried away by its expression of massive grandeur, perfect proportion, delicacy of detail, and unity of style. Strength and beauty go hand in hand, and, in obedience to the will of the master, impress with reverence approaching awe or fill with delight akin to rapture. These effects every one has felt in some degree, and in the supersensitive they find their fitting expression in tears. Such emotions, awakened by symmetry of form quickened with light and shade, and heightened in its effect by harmony of colour, are the responsive echoes of beauty and art concentrated in noble structures by the great masters of the fine art of architecture. It is to such works I would call your attention while I try to show the intimate relation that exists between this fine art of architecture and the industrial arts, commonly called the applied arts.

Take the cathedral of ancient, mediæval, or even of modern times, what do we find? An idea perfectly fitted to the purposes intended, vast and mysterious, embracing solidity of construction and harmony of proportion; its horizontal lines giving breadth, and its vertical lines giving height; pyramidal in outline, with lofty nave and spreading aisles, and chapelries beyond, the whole stamped with one dominant style, and seeming to be possessed by one spirit of design, speaking one language, light and shade being courted by projections and recesses, and by richly moulded arches and counter-arches, sustained by piers or walls or clustered pillars, blossoming with quaint carvings and diapers, and innumerable fancies, full of charming detail and alive with symbolic meaning.

"A Gothic cathedral," says Hawthorne, "is surely the most wonderful work that man has yet achieved, so vast, so intricate, and so profoundly simple, with such strange delightful recesses in its grand figure, so difficult to comprehend within one idea, and so consonant that it ultimately draws the beholder and his universe into its harmony. It is the one thing in the world that is vast enough and rich enough."

No part of a great church but has a lesson to impart, some impression to make, and every portion of the building is a realisation of the intimate relation existing between the fine and applied arts, in which the mason, the carver, the sculptor, the mural decorator, the mosaic and glass-painter, the lead-worker, the encaustic tile and iron and brass-worker, the jeweller, embroiderer and tapestry-worker, the wood-carver and joiner, meet and mingle, and find their appropriate places, and learn to work in harmony together, aiding in the development of the great idea embodied in the complete structure.

Obviously, however, not only the architect but every artisan needs to acquire some knowledge of the style of art in which he is working, if the spirit of the whole is to be alive in every part. In these days, when the designer cannot be the constructor also (as he was in the old times), when things are done by contract without extras, and under penalties to complete in a given time, it is plain that there is no room for "'prentice pillars," and our workmen must be fitted for their work before they engage in it, and must be taught the elements both of the scientific and artistic principles underlying the arts they apply themselves to realise, otherwise they will be no better than the machines by which so much handicraft is supplanted.

Individual excellence in every branch of applied art is not to be expected; but specialists in each branch may be well calculated upon, each of whom shall have mastered the nature, quality, adaptation, and limitations of the various materials in which his work is to be wrought. Every wood is not suitable for every purpose, every metal is not amenable to the same treatment; iron and steel, brass and bronze, lead and copper, have each their own peculiar rigidity, or malleability, or other suitableness to special purposes, and open out possibilities of variety in design arising from the different conditions of the material of cast, wrought, or molten metal. Encaustic tile and tesselated pavement, mosaic floor and wall decoration, terra-cotta and ceramic ornaments, gold and silversmiths' work of every variety, have each and all divers ways of realising artistic ideals, and knowledge or ignorance of the fundamental conditions ruling their successful manipulation, makes or mars the resulting composition. It depends upon the thoroughness with which these underlying principles and foundations of artistic design are grasped that ease and rapidity of workmanship will be attained, even by the born artist.

It is here that the various art guilds and co-operators may do good service in association with technical colleges. It is here that the Arts and Crafts Exhibition has done, and will do more, such service, as time rolls on, and the scheme is developed and less confined to one phase of art. It is here that the Society of Arts' money prizes, offered for competition through the Applied Art Section to the workmen employed by the great firms or otherwise, help to enable handicraftsmen to come forth from the crowd, and be recognised as individually clever men in some one or other of the many branches of the applied arts, to whom architects may look to realise their designs in the spirit of the style employed, and with the personal touch and characteristic force of the worker, and that firm possessed of the greatest number of such men, which is also ready to give a share of its profits in addition to the ordinary wages for special services in higher class art work, will be most coveted and employed by the architect.

In this way the want of capital on the part of the art workman will not handicap him in the race for distinction, the perpetual employment he will ever secure will relieve him from anxiety as the bread winner, and the extra pay he will receive for better class work will compensate him for the time and labour he gives to perfecting his knowledge and making himself an artist workman who needeth not to be ashamed. In course of time he may earn his entire independence and others may take his place; but every artist of whatever grade should be able to look forward to personal recognition and to be admitted into the ranks of those whose artistic aims are akin to his own, and with whose companionship in study and association in work he may gradually rise in his own esteem and in the respect of his fellows, the fitting and chief reward of his enthusiasm, to say nothing of the pecuniary benefits that will surely follow.

And how is this to be done? Variously, and in harmony with the special objects in view. First and foremost the natural and instinctive love of children for imagery, for stories, for pencilling and colouring, and deft fingering should never cease to be cultivated, and every Board school as well as every higher kind of instruction for the young, adapted to the several stations of life among us, should teach drawing as it teaches reading, singing, or cyphering. The free use of the pencil is of incalculable value in any sphere of life, and it gives to those who have a natural taste for it a direct interest in art and develops powers of observation and comparison otherwise unattainable.

Frœbel's kindergarten system of early training of the hand and eye, followed by manual exercises like the Swedish Slöjd, are of singular value up to the ages of 10 or 12 years.

In reference to elementary art education Mr. Wyatt Papworth has done good service in his address delivered at the opening of the Bingley Technical School as Master of the Clothworkers' Company, by calling attention to the difference between schools of drawing and schools of design, pointing out the decadence of the latter and the inferior quality of the former, which, while they do not rise to high art, come short of the necessities of applied art from the absence of encouragement to design for special purposes in various materials for divers manufactures.

Architecture, painting, and sculpture, the triune embodiment of the fine arts, have their fundamental power of expression through drawing with pen and pencil or brush; and that nation which provides the best schools of design and the most perfect system of drawing, colouring, and modelling in the studio and out of it, for every stage in the life of the student, and surrounds its people with the best models and the best tutors, is likely to win in the race for supremacy in both the fine and the applied arts.

Elementary knowledge is not enough, our secondary and higher schools, but especially our technical schools, should carry on the process till proficiency results; and this cannot be in the arts connected with architecture unless it culminates in complete mastery of decorative design and drawing from natural forms and the living model, as well as the practice of geometry and perspective.

The grounding required by artists and sculptors is essential to success in fine architecture and in the applied arts generally; and the idea that in so doing we are not giving a technical character to the teaching is absolutely false, for there is but one method of acquiring the facility to design for any purpose, and that is acquaintance with the forms o nature and art and the power of reproducing them, which must precede their conventionalisation to fit them to the special purposes to which art is to be applied.

The pre-eminence of France in art generally, and its application to industry, seems to have resulted from the recognition of this important preliminary training, practised and persisted in since the time of Colbert. Sir Philip Magnus, in comparing the German system of direct industrial art education with that of France, says the former has no exact counterpart in France:—"For educational purposes the distinction between fine art and industrial art is scarcely recognised in France. Students who are being trained to become trade designers are taught art; their eyes are saturated with nature, and their hands are taught to represent it. Throughout France the evening art schools are filled with artisans, who are instructed in the general principles of design, but who are encouraged to find in natural objects, and particularly in the human figure, their inspiration. Nearly all French teachers emphatically protest against the idea that there are two sorts of art. Art, they say, must be taught as art, and not with a view to its application to silk weaving, calico printing, china painting, paper staining, or any other trade."

Granted this thorough preliminary artistic training, much good might result from technical training in special applications, because, as Sir Philip points out, in the endeavour to add beauty to things around us, the industrial artist works under limitations imposed—

1st.—By the use to which things are to be put.

2nd.—By the material in which the design is to be wrought.

3rd.—By the appliances by which it is to be produced.

Though these difficulties may be overcome in the workshop, much time is often lost from the reluctance of fellow-workmen to impart their knowledge to each other, or to apprentices, and therefore the technical school might advantageously supplement the workshop in imparting the requisite information, that is to say, skill in drawing and modelling, a knowledge of the limitations of the material in which the design is to be fixed, and of the processes by which it may be produced. In France, not only is the teaching of drawing universal, but trade museums are to be found in all trade centres, so that every opportunity is afforded to the French artisan to cultivate his intelligence, and stimulate his exertion to attain excellence in applied art.

Nevertheless, the French may take a lesson from English non-academic modes of personal growth; and our technical courses might profit by the same, and include in their curriculum for applied art study things beyond the range of the class-room, and not to be found in books. Studies from life, embracing not only models but completed works, ancient and modern examples being drawn and measured, chronicled and criticised upon the spot. In short, the method which the architect (whether young or old) adopts to perfect his knowledge of his art, viz., the analysis and comparison of executed works by the best masters within his reach.

The Boston *Technology: Architectural Review* has some admirable remarks on academic training and sensationalism in architecture, which I may summarise as follows:—The purpose of academic training has been to cultivate the sense of the highest essentials of architecture, to develop a knowledge of the best that has been done, and the conditions under which it has been done; and such cultivation and knowledge is only to be attained by slow progressive study, resulting in a power of discrimination, a fine sense of fitness and virtue, opposed to the mere provision of ready-made architectural clothing. As for the class of architectural sensationalists, who plant gleanings from all fields, and whose very flowers bear a strange resemblance to rank weeds, any objection they may bring to an academic architectural training assumes the shape of a boomerang. They have, however, one virtue—that of vitality. Whatever else they may be, they *are* alive, and their very vivacity makes training of any kind irksome to them. From this very erratic, eccentric, but fully-alive architectural invention may come the highest results; but be sure it will take the academic training adequately to produce them. The possession of the power to create is an individual gift, so rare and so beyond price that it cannot be too highly cherished; but the very worth of this power is dependent upon the manner in which it is used and the clearness of its expression. Whether for good or ill, architecture has greater influence on the public mind than any of its sister arts. It is the exponent of dignity, grandeur, ostentation, vulgarity, delicacy, luxury, brutality, and the commonplace and a dozen kindred qualities. Protean in its possibilities, it is constant and conspicuous in its effect; it is perpetually a part of daily life, and stamps its character upon many minds. It is, therefore, a powerful moral agency, and besides expressing the character of its creators, it influences the character of their successors.

While it is perfectly true in the abstract, as stated in the circular convening the Liverpoo Congress on Art, that the artistic quality of a nation's manufactures, and its prosperity through the applied arts, depends upon the high level of excellence in the fine arts, and the position of France at this moment is an outcome and example of the principle involved, because the masters in art are teachers as well as practitioners; yet the reverse of this order is equally true in practice; at all events it is quite possible to overlook other sources of inspiration, which at a critical period in the life of the art student are better calculated to develop the national taste in art; and there is a point at which the "high-level of excellence in the fine arts" ceases to exert its influence on the nation's manufactures, or to raise the artistic quality of the applied arts. That critical period is arrived at when the temptation to become an artist of easel pictures or studio sculpture is too strong for the student in art to resist, and he ceases to qualify himself for the application of his acquired powers to the various industries of the country.

Mr. Walter Crane meets this difficulty by boldly reversing the order of art education, and in his paper contributed to the *Universal Review* of September, 1889, on the "Teaching of Art," says—

> "I would begin with the constructive and adaptive side of art. Let a student begin by some knowledge of architectural construction and form. Let him thoroughly understand the connection, both historic and artistic, between art and architecture.
>
> "Let him become thoroughly imbued with a sense of the essential unity of art, and not, as is now often the case, be taught to practise some particular technical trick or meaningless elaboration; or be led to suppose that the whole object of his studies is to draw or paint every object from the pictorial point of view exclusively."

And he goes on to remark that—

> "In thus giving the first places in a course of study in art to architecture, decorative design, and handicraft, we are only following the historic order of their progress and development."

More revolutionary still is Mr. J. D. Sedding, who, in his paper on "Things amiss with our

Arts and Industries," successfully combats the claim of the fine arts, as represented by the Royal Academy, to be considered the sole measure of improvement in the Industrial arts, and suggests a new departure; but he seems to ignore the fact that in the early stages of its development "there can be no two sorts of art, but that art must be first taught as art," *per se*, and not only in its applications. He says:—

"If it be true that high excellence in the fine arts ensures the artistic quality of a nation's manufactures, then are we right in sinking every consideration for their sake; then are we right in our school of art methods, that would fain regenerate the industries from the summit of the fine arts rather than from the lower level to the higher. If, on the other hand, this premise be unsupported either by historic precedent or by recent experience, then are all our methods radically wrong, and we had better forthwith dig the ground and dung it, and grow our arts and industries as nature grows trees, from the ground upwards.

"Suppose [says he] that I want to test the artistic quality of English art, of any date from the 13th to the 15th century, shall I consult the walls of the National Gallery for specimens of fine art in easel pictures? If I did I should come empty away. Shall I not rather get me to some old church of the first class, and find my answer in its every detail, from floor to crest in fretted roof, carved boss, wall decoration, screens, shrines, monuments, canopied stalls, metal work, tapestries, embroideries, glass windows, and so forth? Shall I not go to some old manor house and consult its fittings and design, in the stamped pattern on the lead waterbutt, the moulding and iron-work of the door, the plaster frieze, the tables, the chairs, the carved bedstead with its embroidered curtains and quilt, the panelled chest, the wainscot, the carved fire-place, the brass fender, the andirons, with their 'two winking cupids of silver, each on one foot, nicely depending on their brands.'

"It is clear that in the case of historic art the artistic capacity of a nation at any given time is better realised by inquiry of the industrial arts than of the fine arts. We learn more by examining what is being done in pottery, porcelain, woodwork, metal work, woven fabrics, &c., than by resort to the high-flown fantasies of the fine arts when not applied to uses of common life. History and common sense are both against our present system of art education, which thinks to make the lower by beginning at the higher. The real live art of olden days differs from our modern make-believe in this, that it proceeded from the very heart of the people, and was not something too good for human nature's daily food, that its device is a thing that evolves itself, and is not full made all at once; that its fresh springs flow direct from the ground of the common arts of life, and not from the filterings of fine art eminences. All true art that the world has ever seen was simple before it was fine, real before it was ideal, strong before it was sweet, it could stand on its feet and walk before it attempted to fly."

Now I fully sympathize with this direct method of attacking the industrial arts, provided always that the earlier stages in the education of the art student have fitted him to profit by it, and that everything is not left to Providence, and the uncovenanted mercy of the chance development of a good eye and cunning hand.

Indeed, these counsels are most valuable as suggestions for the kind of education required at that critical stage, when the temptation comes to the competent student to forsake the practice of the industrial arts for the fine arts pure and simple, to which I have referred.

As a matter of fact, there is no necessary connection between the "high level of excellence in the fine arts" and the improvement of the artistic character of the industrial arts of the country. Like Dives and Lazarus, a "great gulf" exists between them, and to bridge that gulf should be the aim of the higher technical art schools, both academically and sensationally; to enhance the interest and the profit attending adhesion to the development of the applied arts, in preference to the exclusive practice of the fine arts. Just as in physics or chemistry, pure science is directed into technological channels; just as in mathematics, pure and applied mathematics exist side by side with great masters in each, so in the arts there should exist the practice of the fine arts of architecture, painting and sculpture, alongside the application of the same to the industries of the country, great masters being appointed in each department, and no less honour should be paid to the professor of technological art than is already paid to the professor of technological science. Such a course is indicated by Mr. H. B. Bare in his paper on "Schools for Artistic Handicrafts." He says:—

"One important endowment seems particularly needed, namely, a chair of architecture and the allied arts, and a school for the crafts which are in natural alliance with architecture. Before presenting himself, the student must have passed the elementary study of drawing, so that in the studio to which he is now introduced he could practise drawing, painting, and sketching in clay from the figure, arranged with special reference to decorative requirements. He would also be instructed in designing suitably for translating his subject according to the peculiar nature of various materials, whether mosaic, glass, plaster, sgraffito, or painted mural decoration, &c., &c.

"In the laboratory or model workshop he would become practically acquainted with one or more of the crafts through the aid of practical teachers chosen from leading craftsmen in stone and wood carving, metal work, glass painting, mosaic, modelling in clay, and the like. Here, too, he should be afforded the opportunity of experimenting in new processes, and in revising some of the old ones which have fallen into disuse.

"In the lecture hall would be unfolded before him the history of the architectural styles, and this history connected with the principles of design in ornament and the capabilities of different materials for ornamental treatment. All these subjects being amply illustrated by examples from the best periods of art."

In spite of Mr. Waterhouse's objection to academic courses in art and architecture, and his preference for the rough and ready originality of self-taught English artists and architects, I am inclined to think that there is plenty of room for something more systematic than our Bohemian methods. The acknowledged pre-eminence of France in art culture is directly due to the long-continued State patronage of the fine arts and the provision made for art education generally.

In the German system of general secondary education the student makes his choice of the realschule or of the gymnasium—in the former to prepare for the polytechnicum and in the latter for the university—according as his aim in life may be scientific or literary. We are only just beginning to do what the Germans did forty years ago, and like them we are giving to our universities a science side, and our higher technical schools and colleges are taking the place of the polytechnica: but we must go a little farther and have our art side also, and private enthusiasm exemplified in the Slade trusts has opened the way to it. The late Sir Digby Wyatt, in his series of Slade lectures at Oxford, has shown what it is we require in order that the "high excellence of the fine arts" may have any appreciable influence over the industrial arts of the country, and he is well seconded by Ruskin. The representative men of the day, whether architects, artists, or sculptors, must themselves become technological art professors, and forge the links that unite the fine and the applied arts—they must condescend to details and live upon the earth and not always "in the clouds" —then, indeed, but not till then, can they claim to be leaders in the development of the industrial arts.

Professor T. Roger Smith, in his interesting paper on "Architecture as a part of a Liberal Education," aptly describes the sort of instruction in architecture it would be advisable and possible to give to gentlemen, which is also equally appropriate and necessary to the artistic development of the industrial arts generally, the value of which depends so much on unity of style. He says:—

"From the first it should emphatically be given from buildings in preference to books, prints, photographs, or drawings, which are only to be called in as aids. Architecture is buildings, not representations of them, just as sculpture is statues, or botany is plants. To begin with, the pupil should have a competent power of drawing, and should draw for himself; and his tutor should from the first take his class to some building that has a claim to be considered as architecture, and should show them of what (looking at it as an architectural object) it consists, to what style of architecture it belongs, and such other facts about it as careful inspection will elicit. He should point out, or lead the learners to discover, the character or nature of the building as a work of art. How many of Ruskin's seven lamps shine out from its midst, and has it perhaps some other qualities which he did not hold to be lights? and what are its blemishes? When thus one building has given the students an idea of what architecture is materially and spiritually, they should then study a series of buildings constituting illustrations of the development of our own national style, and for this purpose no series exists so good as English Gothic from Saxon days to the Reformation. When this second step has been taken with some degree of thoroughness, I would then attack the history of architecture throughout the civilised world."

I dare not quote other authorities or corroborative opinions, since time would fail me; but it must be obvious to all that the spirit of the age points to the increasing importance to be attached to the study of things, in preference to words; to the work of the laboratory as a complement to the teaching of the class-room; to manual as well as mental labour; to outdoor observations as well as indoor studies. Sketching parties have become a necessity, not a novelty, and instead of annual excursions, monthly and weekly sketching clubs are forming, and daily becoming more popular among students of architecture.

I agree entirely with Mr. Walter Crane's closing passage in the charming paper already referred to, viz.:—

"I do not believe in any cast-iron system of education from any point of view. It must be varied according to individual wants and capacities. It must be made personal and interesting, or it is of little good; and no system, however efficient, will manufacture artists in anything, any more than the most brilliant talents will do away with the necessity of passionate devotion to work, careful thought, close observation, and constant practice, which produce that rapid and intimate sympathy of eye and hand, and makes them responsive and fluent interpreters of that selective and imaginative impulse which results in art."

I have quoted liberally from the "Transactions of the Liverpool Art Congress," in the hope that it may not be overlooked and buried with other transactions in the hidden recesses of old libraries; this first effort on the part of the leaders in modern art progress to arrest the attention of the English people to their artistic shortcomings is a valuable contribution of earnest, almost pathetic appeals.

The perusal of that work leaves an impression on the mind that there is some dissatisfaction at present existing in the art world at the illogical and incomplete way in which higher art education is carried on in this country. Spasmodic efforts are made by small bodies of enthusiasts, whose labours are carelessly criticised, but whose honest, self-sacrificing purposes are but little appreciated by a public which cares for none of these things, and calls them cliques, and would class "The lunatic, the lover, and the poet" in one category, "as of imagination all compact," and therefore, not worthy of the serious consideration of practical men. The "Transactions of the Edinburgh Congress" will be no less interesting and instructive than the first.

I fear it must be admitted that the culture of the artistic powers too commonly ceases at mediocrity, or if carried beyond, drifts into picture painting, which results in still further stocking a glutted market with second-rate easel compositions, powers which might otherwise have issued in the production of men entitled to be rated masters of the applied arts.

Universal geniuses in art, like Sir Frederick Leighton and Prof. Herkomer, are too rare to be quoted in opposition to my assertion, that specialists are needed in every branch of the arts to bridge the gulf, and not a few brilliant stars only, the high excellence of whose achievements in art are no measure of the prosperity and growth of the applied arts generally, valuable as they must be as exemplifications of the successful practice of the fine arts.

What we want are schools like Herkomer's at Bushey—where the fine arts and the applied arts may be seen, taught, and practised in the same place.

At Bushey, the ablest artist of the day is daily painting his wonderful pictures, or etching plates for reproduction, and instructing pupils at the same time.

The master may be seen designing lovely iron grilles, and welding them with his own hands, or carving elaborate screens in hard ornamental woods, or chasing metal plaques, or executing delicate embroideries, and all that is required to furnish the house which is to be years in building, so that all the applied arts, inspired by the same genius, may breathe the spirit of the fine arts, and become examples of the harmony which should subsist between them.

The school of art here flourishing is scarcely known outside a privileged few, but the founders of every technical art school in the country should visit this spot, and drink in the spirit of the place, and straightway proceed to produce, as nearly as may be, another such oasis in the desert of art culture in Great Britain.

I do not know what men of mark have risen out of this Elysian garden, but the result should be far more efficacious than any number of elementary polytechnics that seem to have taken the public fancy as a possible means of elevating the arts and crafts generally. Thoroughness is most required, and not mediocrity. Architects like the late Pugin, Street, and Burges were men of the same stamp, and were workers as well as designers, and had a school of earnest followers.

I have not spoken of the work of South Kensington, because, in spite of its shortcomings, it needs no praise at my hands as an elementary impetus. All who have troubled themselves to observe the progress of late years, since the appointment of Mr. Poynter and his able subordinates, will be ready to recognise the value of the work done, and the immense interest it must have excited throughout the country, to obtain the rewards held out to superior merit. The specialisation of study to local industries is the part which belongs to secondary education.

If the improvements in details which every year suggests are continued, it is difficult to construct a better organisation at present available for the preliminary development of the taste of the masses. What has been done for elementary education and lower middle-class schools, under the pernicious system of payment by results, needs to be carried on to a higher range in the secondary schools and colleges; for nothing but the very best in every branch of science or art can now make the balance even, and keep it so, between ourselves and foreign competitors.

No teaching, however humble, based on sound principles, is to be despised or hindered—for everything must have its beginning—but only the highest culture can hope to carry all before it, and raise the standard of our national taste to a level with, or in advance of, the rest of the world.

As Ouida makes her hero Pascarèl say of Florence:—

> "It was not only the great men that made her what she was. It was, above all, the men who knew they were not great, but yet had the patience and unselfishness to do their appointed work for her zealously and with every possible perfection in the doing of it.
>
> "It was not only Orcagna planning the Loggia, but every workman who chiselled out a piece of its stone, that put all his head and heart into the doing thereof. It was not only Michael Angelo in his studio, but every poor painter who taught the mere A.B.C.D. of the craft to a crowd of pupils out of the streets, who did whatsoever came before them to do mightily and with reverence.
>
> "In those days all the servants as well as the sovereigns of art were penetrated with the sense of her holiness. It was the patient, intelligent, poetic, and sincere servitors of art who, instead of wildly consuming their souls in envy and desire, cultured their one talent to the uttermost, so that the mediocrity of that age would have been the excellence of any other. Not alone from the great workshops of the great masters did the light shine on the people."

[The paper was illustrated by a series of photographs of foreign buildings on the walls, and by a series of lantern slides of English cathedrals which were thrown upon the screen.]

DISCUSSION.

The CHAIRMAN said they must all be much obliged to Mr. Robins for this paper, but he feared he (the Chairman) was somewhat of a heretic on the subject of the relation of the applied to the fine arts, being rather of opinion that there was no art but applied art. No art could exist apart from materials of some kind, and it must, of necessity, always be applied to and expressed by them. It seemed to him that there was a great difference between art and science, and in that difference perhaps lay the whole difference in teaching it. The most abstract art was after all concrete; it could not be reasoned out apart from demonstration as pure science might, and possibly people might be misled if they looked forward to devising an absolutely perfect system of teaching. He could not help responding heartily to the remarks of Mr. Sedding which had been quoted; in fact, the question of the relation of the applied to the fine arts might be said to divide the house of art into two parties, those who looked to grow the tree downwards, and those who preferred Nature's plan and progress from below, and he decidedly threw in his lot with those who looked to its growing up from the ground rather than to endeavouring to improve the arts of design by making what is called "fine art" grow downwards. In any particular period when the arts flourished every detail of ordinary life was beautifully designed, and all was done without trouble and as a matter of course. In these days it was infinitely more difficult to make sure of having ordinary things of use beautifully designed and well wrought than to have extremely talented drawings and paintings from nature or representations of natural scenes. Anyone who had tried both would tell you that it was comparatively easy to make a pretty sketch from nature, but an entirely different matter to think out a design which should satisfy a workman in its technical conditions and satisfy also the conditions of use and the sense of beauty. Although he quite recognised, for temporary purposes, the convenience of making a distinction between fine and applied art, it was desirable to remember that they were but nominal and artificial. In this century we seemed to be going wrong by dwelling on this hard and fast line of distinction between the arts rather than on their resemblances, and we were now trying to bridge the gulf which Mr. Robins spoke of. Until that was done, we should not get either very fine art or very good applied art. The best education, as regards art, although our education in many cases was far more complex than any education ever was before, would not compensate for the loss of beauty in life. Until we could give the mass of the people access to the beauties of nature and some kind of refinement, the struggle was hopeless. We might succeed in getting some little island of delight here and there for a few cultivated people; but the immense mass must remain in comparatively outer darkness while the present conditions continued. He was not one of those who thought we were condemned for ever to the present system of fierce competition, not only amongst ourselves but as against foreign nations; he rather looked to a system of association and co-operation because man had shown his capacity in that direction quite as much as in the direction of selfish individualism. These questions were after all closely connected with art. If we inquired into the origin and causes of the different types of architecture that grew up, and looked at our own cathedrals, they were not purely arbitrary emanations of human genius; their causes lay in the organisation of the society of the time, for all art, of whatever form, must reflect the character of human life. It was very obvious that our present art was affected by the characteristics of our present life, and that most of our deficiencies in this matter were owing to the prevailing commercial system, which hardly gave time for proper thought, or the production of really beautiful works of art for their own sake in matters of use and industry. If you sought to have a thing made specially by a workman to a particular design, and to give him full scope, in the first place, it was difficult to find a workman who was an artist in that sense, and it would cost very heavily in time, trouble, and money, probably out of all proportion to the result. It might be said that that was because men only worked now in association, owing to the subdivision of labour and the application of machinery, and that to correct that, our only hope was to rely on good designs being supplied. That might be so; but if so, it was a bad look-out for the handicrafts, except so far as they concerned a comparatively limited public.

Mr. Lewis Day, after expressing his high appreciation of Mr. Robins' paper, said that on one point he differed from him entirely. He understood the reader of the paper to say that a man must first be taught art as art, regardless of whether he was going to be a painter, a designer, or a carver. Of course, he did not mean to say that a man's education from the beginning should be simply a training for his future career; but he did not believe in first educating a man in art, as it was called, and then leaving him to shift for himself to earn a living. That had been the practice in the schools very largely, and the result had been that when a young man had been what they called "trained," he found himself thrown on the world with no means of making himself of use in it. He had come in contact with scores of young men who had split upon that rock. He did not think Mr. Robins quite realised what an enormous thing the very smallest of the arts was, and what a deal of work went to it. If a man were only going to make patterns, that was quite enough for him to master, and he might spend his whole life without perfecting himself in that. If he began by trying to paint pictures he would never know where to end. Theoretically, it might do if there were time enough. Practically, the whole system of teaching to design must be different from that of teaching a man to paint. The painter, for example, when he made studies from nature, looked at a thing quite differently from the designer; he looked at the relations of things, at the tone, and atmospheric effects, and so on, to say nothing of devoting his attention to the technique of painting; but the designer looked rather at the construction and growth of a plant, and the ornamental turns and suggestions in it. The whole force of his mind was bent in an entirely different direction. If a great painter were put to design ornament on the lines of nature, though he might paint landscapes, or even flowers, he might prove not to know so much of the construction of certain floral forms as a journeyman designer who had been taught his trade. Mr. Day could not agree that genius was simply the power of taking pains; it was something very different. Taking pains went to making genius effective, but no amount of taking pains made genius. On one other point he rather agreed with the Chairman; although they must make a distinction between fine and applied art for the purpose of discussion, he could not quite see why they should drag in fine art as applied to all sorts of things. Mr. Robins alluded to fine art in lace designing, and other things of that kind, but he thought the arts were a great deal too fine; and if applied art would be content with calling itself art, or simply craft, he should much prefer it.

Mr. Forbes Robertson could not agree with Mr. Day that the initiatory art training was unnecessary for a man who went into an occupation other than that of fine art. In order that the pattern maker might conventionalise the flower before him, or whatever he might wish to utilise, he must have the alphabet of art at his fingers' ends, and the use of the pencil; he did not say painting, but the use of the pencil ought to be taught in all schools. He had been much pleased with the illustrations, which no lecture on art ought to be without. The influence of architecture which had been so admirably emphasised was a very potent one wherever art existed, and until one could walk down a street which impressed one with its beauty and variety, this could never be called an art nation. Why had the French so much more art feeling than the English, and no one could doubt the fact who was familiar with France. When you got to Paris you felt you were in the great art metropolis. Many reasons might be adduced; first of all they began their technical training in art a century before we did. Charles Lebrun flourished 100 years before Sir Joshua Reynolds. The accidents of history had been in great measure against us ever since the country came to be called England. There had been so much war and bloodshed, first on the Continent and then between that end of the island and the north, that we really had not much time to study art, and our great commercial genius had not then arisen. We were simply the exporters of rough wool to the Continent, which the weavers of Flanders made into fine art products. Our great commercial preeminence was only a thing of yesterday; and no country ever rose to any eminence in art except alongside of a commercial and manufacturing spirit. This could be seen in the case of Germany, Italy, or France. He thought Mr. Robins was quite right in distinguishing between pure and applied art. Gibson's Venus at Rome was art pure, simply made for itself; but when you took the female figure and made it an element in a mantel-piece or fire-place, as Stephens did in that fine house in Hyde-park, it became applied art. In the Medicean palaces of Florence you saw the same thing. There Michael Angelo used his great powers in carving those glorious figures on the tombs and in the chapels. Now, did all this teaching affect us as a nation? Were we really going ahead, throwing more sympathy with artistic work into the hearts of the people? Looking back to the period of the Renaissance, there were no technical schools then, they had simply the trade guilds; and some of the greatest masters served their apprenticeship, and did all the work connected with the manufacture of paints and the making of brushes; and at the same time that they were painting great pictures they would paint bridal chests, and cradles, or a shield for some family newly enriched by commerce. He doubted whether these technical schools were going to bring about like results. They could not infuse art into the people any more than the Board schools would infuse morals; they were separate things entirely.

Mr. H. Stannus said he would venture to draw a distinction between science and art which Mr. Robins had not done. Every discovery in science was added to the common stock of knowledge, and every schoolboy might start with a knowledge of science infinitely beyond what was possessed by the great men of the middle ages. But it was different with art; that had to be acquired by each man for himself; he had to learn to draw, to paint, or to model. Thus it followed that while science always kept on increasing like a flowing river of irresistible volume, art sprang up, and died down, and then sprang up again. It had its times of ebb and flow, while science was always in a state of resistless flow. With regard to applied art and fine art, he thought the question would be much better understood if the term fine art were discarded. He should divide the arts into representing or recording arts; suggestive or symbolic arts; and decorative arts. The aboriginal savage who scratched the reindeer on the horn, which could be seen in the British Museum, was not thinking of anything suggestive or decorative, he was only representing: it was the art of facts. There came a time when representing art was made the handmaid of religion, and then, in addition to representing fact, it was also called upon to suggest things, and then it became symbolic art; but in neither of these examples did people think at all about decoration. Lastly, they saw that these representations and suggestions on objects made them more beautiful, and then, of course, art became decorative. Mr. Day, in one of his text-books, had pointed out, with singular acumen, the double source of art, as representing and decorating; but he should prefer the triple division he had mentioned. Representing art was not applied art, neither was suggesting art. It was when either of these two was applied to the decorating of some object of utility that decorating art came in. Hence he would say that architecture was not necessarily a fine art, but an applied art; it was applying proportion variety, axiality, and principles of that kind, to the problem before the mind. Hence, although one liked to think architecture, as the mother art, was a grand thing, if they were compelled to draw distinctions it must be recognised as an applied art. With regard to the education of the artist, various suggestions had been made, all correct from different points of view. He would like to follow the principle that the man who was going to be "a picture maker," as the late Mr. Beresford Hope used to call it, and a very good and honourable term too—artist was too ambiguous—and the man who was going to be a decorative artist need not necessarily be educated in separate buildings; that tended rather to lower the ideal of the decorative artist; he should be educated alongside the man who was going to paint the finest pictures and make the finest statuary possible, up to the point at which the paths diverged; but while he was so being educated he should also be practised in designing. At South Kensington, the two classes were educated side by side, but the man who was going to be a painter, once a month was practised in figure composition to a given subject, and the man who was going to be a decorator had for his monthly practice to design a given object, with a given material, and of a given size. In that way the man all through was feeling his way, and it was at any rate a sensible training. It was sufficiently elastic to find out a man's strong and weak points, and they tried not to spoil a man's genius, but rather to develop it along the lines it was calculated for, teaching him also the grammar of the art. There might be mute inglorious Miltons, and they would remain mute and inglorious until they learned the grammar of art. Mr. Robins had given a great deal of self-denying attention to the various methods of forwarding applied art, and the country would some day feel its indebtedness to him and men like him. His paper had brought into a focus all the various items of knowledge on the subject, and he had much pleasure in moving a vote of thanks to him for it.

Prof. Ayrton, F.R.S., said the question had been put whether in the past there were any technical schools. He thought there were very splendid examples of them. The school of the painter David was the *beau ideal* of a technical school; in it was done very much like what Herkomer was doing now at Bushey, working himself, not confining himself to one part of his profession, but taking all parts from the highest to the lowest, working with his people all round him, and imbuing them with his own ideas. He was not a schoolmaster in the sense of merely teaching, because he was also a designer and manufacturer. If men with the same kind of views—men who had a reputation in their own professions, and not schoolmasters nor these who looked down on practical applications — were appointed to superintend the teaching, whether in technical schools of art or science, then those establishments would do very valuable work indeed. In the past all art was applied. In going to countries less advanced than our own but much more artistic, practically there was no distinction between what some people called fine art and applied art. There was no distinction made in Japan, for example, between the artist and the workman; the workman was the artist. He was a magnificent workman and also a magnificent artist, and he often had a school of pupils around him who were artists and also workmen. One of the first things which struck an Englishman in Japan was finding that there was no distinction made between the designer and the workman. There had gradually come about, in the northern countries of Europe at any rate, a distinction, and there were a number of men who desired to practise the fine arts and rather looked down upon the application of art to industry. There certainly was that class of men in science, a class which had grown up amongst the teachers of Universities who taught what they considered pure science, and rather despised any application of it. That was obviously an exceedingly bad state of things, and the object of this movement for technical education was to bring together science and its application to industry. Happily, there were one or two men at the Universities who taught science and its applications, and who appeared to him to be like David and Herkomer, splendid examples of technical instructors in art and science. He might refer especially to Sir William Thomson, of Glasgow, the most pre-eminent man in pure science certainly in Europe, and probably in the world. He was a magnificent mathematician, and also one of the best technical educators living. Some years ago, when Sir William was asked by the Commission on City Guilds to tell them something about technical education, his answer was that he did not know what technical education meant; but what he ought to have said was he did not know anything else, because his whole system of teaching was technical. If a practical problem had to be solved, he would apply the highest mathematics and most advanced experiments to solve it, and would work at the apparatus or machine himself, put in the screws, and so on, just as as if he were a workman. That was an example of what had been going on for many years of real technical education, and such examples ought to be copied. Mr. Robins had rather given the impression that the Central Institution would have nothing to do with art, either fine or applied, but the explanation was very simple; there was not sufficient money at present for the applied science teaching, and therefore it was impossible to think of teaching any kind of art or architecture.

Mr. J. D. CRACE agreed with very much which ad been said both in the paper and in the discussion. With respect to art education, whether of the higher form of art, or of art crafts, there was much to lament in the loss of apprenticeship, for no technical school, however beautifully organised, was equal to the workshop under the master's eye. Technical schools might perhaps offer the best available substitute, but he doubted whether they would produce better results. The one technical school which had been referred to was not very encouraging in its results. The school of David was as good as anything could be in the way of organisation, but what was the result? During the whole of French history the lowest point in art was touched about the time that David's school was exerting its influence. Of course, the state of the country at the time must be borne in mind, and the crushing influence of one great tyranny, and the whole of the national energies being thrown into other directions, which must always exercise a baneful influence on the art instincts of the people. Mr. Forbes Robertson had referred to that point, and our own art history, and the almost entire cessation of anything which could be called art at the latter part of the last century, and the beginning of this must be attrributed to the complete isolation of England from all art influences for many years, and the entire absorption of the interests of the people in a great war with half Europe. In the face of such evidences art could not prosper. There was much to be hoped for in the present condition of art in England. His own feeling with regard to the so-called distinction between the various forms of art was that it was very unfortunate that at all art exhibitions that distinction was drawn. If people could see in the same building, at the same exhibition, art products of all kinds, not distinguishing between fine art and applied art, it would have a most excellent effect. Only two years ago there was an exhibition of the old masters at Burlington-house, at which one room was devoted to applied art, and no one thought of drawing much distinction between the art in that room and the art on the walls of the adjoining galleries; but everyone crowded into that room almost to the desertion of the others. If they could see in London all the best art-producers of the country sending their work, whether on canvas, in marble, or in the minor arts, such as higher forms of pottery, to one exhibition—an art exhibition, not a crafts exhibition — it would do more towards bridging over the gulf which had been spoken of than anything which could be done in a practical form. Every young artist found that art in a gilt frame was supposed to be higher than art applied to a piece of silver or ivory, quite apart from the excellence of the latter, and he was ambitious to do the best, and so be thought the best of; and the consequence was that you found hundreds of men attempting to gain a livelihood by painting for exhibitions who would have no difficulty whatever in earning a living in art applied to other substances than canvas.

The CHAIRMAN, in putting the vote of thanks, said he might make one remark on a point mentioned by Mr. Forbes-Robertson. He said that art had always flourished side by side with a great development of commerce, and that was true in the past, but there was an essential difference between modern commerce and anything which had gone before. The commerce of Venice, for instance, which was in association with a high development of art, and other mediæval States, differed entirely from our commerce, which depended on a universal world market. Our condition was almost like the old story of Time devouring his own children. No sooner was a beautiful design created, than thousands and millions of copies of it were multiplied in all sorts of ways, and the thing was utterly ruined. Apart from that, the modern system allowed no time for thoughtful production, but everything was produced at breakneck speed, in competition not only with our own countrymen but with other nations.

The vote of thanks having been passed,

Mr. ROBINS, in reply, said he had derived a great deal of information from the discussion; probably some of his opinions would be modified by what he had heard. He should think over the matter carefully, and at some future date they might compare notes again. His was an attitude of earnest inquiry, in the hope that those most interested in the matter would aid him in developing a scheme for applied art education more suitable to our local requirements, and more acceptable to the country at large. He sincerely hoped that the matter would not end where it now stood, but that a real effort would be made to realise the ideal applied art college he had endeavoured to foreshadow.

EIGHTH ORDINARY MEETING.

Wednesday, January 29th, 1890; Prof. W. C. ROBERTS-AUSTEN, F.R.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Burnie, Alfred, 165, Fenchurch-street, E.C.
Dell, Holland, Cowley-villa, Sunnyhill, Streatham, S.W.
Griffin, Beverley, Mount Pleasant, Rickmansworth, Herts.
Newman, Philip Harry, 45, Broadhurst-gardens, South Hampstead, N.W.
Parry, Edward, 28, Park-row, Nottingham.
Redman, Joseph Fell, 165, Osborn-road, Forest-gate, E.
Tidy, Charles Meymott, M.B., 3, Mandeville-place, Manchester-square, W.

The following candidates were balloted for and duly elected members of the Society:—

Allinson, Thomas Richard, L.R.C.P. Edin., 4, Spanish-place, Manchester-square, W.
Bartholomew, William, 82, Belvedere-road, Lambeth, S.E.
Blundstone, Samuel Richardson, 8, Catherine-street, Strand, W.C.
Coomber, Richard William, Tintern-house, Fishponds, Gloucester.
Cudworth, William, Upperthorpe, Darlington.
Davidson, Samuel Cleland, Sirocco-works, Belfast, and Killaire-house, Crawfordsburn, Co. Down.
Docwra, Colin, Old Park-house, Palmer's-green, Middlesex.
Liberty, John Barnes, 36, Belsize-square, N.W.
Liley, Henry G., Radnor-house, Radnor-place, W.
Lupton, Kenneth, Vulcan-works, Coventry.
Lye, W. T., The Firs, Luton.
Palmer, Thomas Cassinet, 121, Adelaide-road, N.W.
Seal, Stephen, Coxbench-house, Darfield, near Barnsley.
Seaton, Albert Edward, Earle's Shipbuilding and Engineering Company, Limited, Hull.
Veevers, James Mallett, Gas Works, Denton, near Manchester, and Mayfield, Denton.
Whiting, William Henry, Fiona, Vanbrugh-hill, Blackheath, S.E.

The paper read was—

THE UTILISATION OF SLAG.

BY GILBERT REDGRAVE.

Few problems are of greater importance to the manufacturer of the present day than those relating to the utilisation of waste products, and in these times of fierce competition in all branches of industry the mere question of the profitable employment of some bye-product often becomes the turning-point in the success or failure of some staple article of manufacture. This is pre-eminently the case in the so-called chemical industries—alkali making, the production of the various derivatives of coal tar, the manufacture of bleaching powder, &c., but it applies also with little less force to the more wide-spread smelting industries and to all manufacturing operations involving the large use and necessarily, also, *the waste* of fuel.

The annual production of cast iron in the United Kingdom amounts at the present time to about 13,600,000 tons, and taking the weight of the slag produced at 1½ tons per ton of pig iron, we may assume that the vast heaps of this comparatively refuse bye-product are increasing at the rate of upwards of eighteen millions of tons annually. Not only do these heaps cover many thousands of acres of land, rendering the same barren and unprofitable, but in some cases, where sufficient vacant ground cannot be obtained near the works, manufacturers are compelled to rid themselves of the slag by conveying it away to considerable distances, or by casting it into the sea, at a very heavy annual expenditure. But slags in immense quantities are produced also in the new processes of steel manufacture, as also in copper-smelting, and the scoriæ from these industries go to swell the vast accumulations which now disfigure the land wherever smelting operations are carried on.

It is no wonder, then, that numerous attempts have been made to find uses for this material and the records of the Patent Office teem with suggestions for turning this slag to practical account in a great variety of ways. I propose this evening to notice a few among the many recent proposals for the utilisation of slag, giving preference to those which have proved of commercial utility, and in so doing I wish to treat of the matter rather in continuation of the able paper contributed to this Society by Mr. Charles Wood of Middlesbrough, somewhat more than nine years ago. We owe to Mr. Wood so many improved methods of dealing with slag that I am justified in speaking of him as the pioneer of slag utilisation.

I need not detain you with the chemical theories of slag production more than to point out that the slags made from each description of ore vary in their composition, though the quality of slag from one and the same class of ores is wonderfully uniform. Thus, the analyses of the slags from Scotch black-band ironstone with which I have been favoured by Mr. David Cowan, the manager of the famous Carron Iron Works, showed on the mean of 28 analyses for the years 1887-1888, and of 25 analyses for 1888-1889, a range of less than ½ per cent. in the silica, while the extreme variation in the total of the bases, lime and alumina, was less than 1½ per cent. over the two years. In some analyses of Cleveland slags extending over ten years these differences are even smaller than those I have just given. It will be understood, and, indeed, is at once evident on glancing at the table of slag analyses (p. 230), that all descriptions of slag have this one fact in common that their three chief constituents are silica, lime, and alumina, the silica being, so to speak, the acid which neutralises the other two bases. Slags are, from the chemist's point of view, a species of impure glass, and they in so far resemble glass that when rapidly cooled they are apt to fly to pieces. In order to preserve castings of slag intact they require to be slowly cooled or "annealed," as it is termed.

In their fracture slags vary almost as greatly as they do in their composition, but in the large majority the surface, when broken, most closely resembles that of basalt. There is often a thin outside crust of a glassy nature, beneath which the granular structure makes its appearance. The exterior of a block of slag which comes in contact with the atmosphere is said to be "chilled," and such slag has almost invariably a smooth glassy skin, which differs both in hardness and texture from the fracture of the interior. Moreover, blocks of slag which have been thus chilled are often coated with a white powder, which Mr. Stead, the eminent chemist of Middlesbrough, who has paid much attention to this subject, informs me is due to the partial decomposition of the double silicates and the formation of a thin film of silicate of lime.

Before I pass on to treat of those uses of slag which will form our special subject this evening, I may briefly remind you that Mr. Wood brought under the notice of the Society, more especially the various methods of utilising molten slag by casting it into blocks, &c.; its employment for the production of slag sand, by running this molten slag into water, a process patented by himself; and the preparation of bricks and mortar from this sand in various ways. These uses I do not therefore intend to dwell upon this evening. I may, however, state that the casting of blocks has made important progress in recent times under the Tees Scoriæ Brick Company, who are now working under the patents of their engineer, Mr. Dobbs. One of the objections to the use of slag blocks as paving setts is the regular smooth surface they possess, due to their production in moulds. The ideal surface would be that presented by the face on cleavage, and, by a very simple expedient, this surface is now obtained:—namely, by casting two blocks together with a notch round them. By means of a smart blow these blocks are subsequently separated, and we obtain the so-called "granitine" paving-setts, a specimen of which I have here this evening. The slag, being non-porous, makes a very clean road surface, and some channelling and paving at Middlesbrough, executed eleven years ago, and exposed to heavy traffic, is still in good repair.

In the process of annealing, the slag is much toughened, and its density is increased nearly 5 per cent. It will not anneal perfectly unless it is practically free from the oxides of iron. The annealed slag has a very strong affinity for Portland cement, and unites with it into a concrete of remarkable toughness. This fact has been turned to practical account by the Jones's Annealed Concrete Company, of Middlesbrough, who employ this material for paving purposes. Used in this way, the surface is pleasant in point of colour, and has little tendency to wear smooth and become slippery under heavy traffic, which is a difficulty with granite concrete pavements. I have some specimens of this material here this evening, and I have recently examined some paving executed *in situ* round the Middlesbrough Town-hall, which shows that this concrete, carefully laid, makes a first-class pavement, at little more than half the cost of York stone flagging.

Large quantities of slag broken by machinery are used in various parts of the country for road-making, and the slags resulting from the smelting of the clayey ores of Northamptonshire yield an admirable material for this purpose. Messrs. Butlin have sent me some samples of broken slag from their Irthlingborough Ironworks, of the best quality, for use as macadam. Such slags should contain about equal proportions of lime and silica, and from 7 to 8 per cent. of alumina.

We may now pass on to consider those derivatives of slag which I have more especially selected for notice this evening; and here, again, I must begin with a material which we owe to Mr. Charles Wood—namely, the so-called "slag-wool," or "silicate-cotton." This substance was, it is true, discussed at the meeting in 1880, but since that time many novel and ingenious applications of slag-wool have come into notice. This material is obtained by causing a jet of steam to impinge upon the stream of molten slag as it issues from the furnace (an air jet would answer the purpose equally well, but it would be more costly). This has the effect of dispersing or breaking up the slag into countless small bead-like particles, each of which, as it flies away, carries behind it a delicate thread of finely-drawn or "spun" slag. I here use the term spun in the same sense as it is employed with reference to glass, which when melted can be drawn out, as you are doubtless aware, in a similar way.

The process of manufacture is based upon the same property possessed by the slag, namely, that permitting of its being drawn out into extremely delicate filaments. To take a homely simile, this method of producing "slag-wool" or "silicate-cotton" may be compared with the production of the threads which attach themselves to sealing-wax when hastily withdrawn from the paper. Each bead of slag produced by the jet of steam carries behind it a tail or streamer, many yards in length, of slag filament. In order to collect the fibres, and to separate them from the beads or heavier portion of the slag, the jet is arranged at the mouth of an open cylinder of sheet iron, in which a strong air-current is induced by means of additional jets of steam. This tube or shaft is furnished with a shield or striking-plate which detains the heavier particles, the lighter slag-wool being carried by the draught upwards and onwards into a large chamber like a gigantic meat safe, having its walls formed of wire-netting with about sixteen meshes to the square inch. Here the steam condenses and escapes, and the "slag-wool," which has much the appearance of flakes of snow, is deposited on the floor and round the sides, the lightest portions being carried to the greater distances, some flakes even attaching themselves to the ironwork of the roof. The filaments of slag formed in this way, though of considerable length, are of such delicacy and fineness that they are broken up into numberless fragments and felted together into a substance much resembling "cotton-wool. Mr. Wood found that this "slag-wool" possessed many valuable properties, which may be briefly discussed:—

1. It is extremely light, and is absolutely fire-proof;

2. It is a marvellous non-conductor of heat and of sound; and

3. It is so porous that it will absorb large quantities of water, and readily retains the same for a considerable time.

These properties of mineral wool have been taken advantage of by the firm of Frederick Jones and Co., of Ryland-street, Kentish-town, who adapt this material to a variety of useful purposes, some of which I am enabled to bring under your notice.

First, as respects Fire-proofing.—The slag wool is enclosed between two thicknesses of galvanised wire netting, as in the accompanying specimen. The netting is kept at the proper distance apart by loops of wire passing from front to back, and the layer of slag-wool of a suitable thickness (one inch has been found sufficient for every purpose) is compactly felted between these two sheets of netting. Prepared in this way, very tough, light, and flexible sheets of so-called "Silicate Cotton Wire Net Felting" are obtained. It has been found that, in the thickness of one inch, one ton of the slag-wool will cover 1,800 square feet—say 1¼ lbs. to the square foot. In this form the slag-wool may be employed under joists instead of pugging, as a lining for corrugated iron buildings, sheds, &c., and for many other structural purposes. Being a non-radiator of heat and cold, it appears to be specially adapted as a lining for temporary buildings either in extremely hot or extremely cold climates. It is, moreover, absolutely vermin-proof, and resists the attacks of the dreaded white ant. Owing to the vast number of minute air-spaces distributed through it, the felt is also a powerful non-conductor of sound, and its employment for this purpose has been attended with excellent results. Combined with Hitchin's fire-proof-plaster slabs, it may be employed with advantage in replacing ordinary lath-and-plaster work, thus attaining at once a dry and non-combustible material, for ceilings, &c. The slag-wool may be introduced dry on a layer of sound boarding in a thickness say of 1½ inches to replace pugging, which latter material, in consequence of being used wet, is a fruitful source of "dry rot." It may also be packed round joists, or employed in a loose state as a backing for fire-grates. The results of practical experiments with slag wool used in this latter way have shown that the heating power of a fire is greatly enhanced by compelling the radiation from the stove to take an outward direction, and, further, that the combustion of the fuel is much more complete when the space behind the grate is occupied by such an excellent non-conductor. In proof of this latter property of the slag-wool, I may point out that if a layer one inch in thickness is held over a gas-jet it is possible, while the under surface is nearly red hot, to place the hand on the top without discomfort. As a covering for boilers, steam-pipes, &c., the silicate cotton takes a very high rank among non-conductors. (See Table below.) It also may be employed with advantage for lining refrigerating chambers, as the following experiment made by Mr. T. B. Lightfoot, C.E., in 1885, will show. Two blocks of ice, each weighing 30 lbs., were placed in separate boxes, the one being surrounded by two inches of slag-wool, and the other with six inches of charcoal. After three days the boxes were opened and the unmelted ice was weighed. The block surrounded by slag-wool weighed 13 lbs., that surrounded by charcoal weighed 5½ lbs., thus proving that two inches of slag make a much better non-conducting lining than six inches of charcoal. As a lagging for pipes, flues, &c., it can be applied woven with yarn into flexible sheets capable of being readily fitted to any surface.

The Relative Conducting Powers of Various Materials used as Boiler Coverings.

Silicate cotton or slag-wool	100
Hair felt	117
Cotton wool	122
Sheeps' wool	136
Infusorial earth	136
Charcoal	140
Sawdust	163
Gas works' breeze	230
Wood and air space	280

In order to test the fire-resisting properties of the slag-wool, several interesting experiments have been carried out to which I may briefly direct attention. After the great fire at Messrs. Rylands', in Wood-street, permission was given to the builder, Mr. A. Braid, of Chelsea, to have a wooden door lined with a 1½ inch thickness of slag-wool, *i.e.*, wood on both sides, with the slag wool packed in between, and fitted into the party wall close to the place where the so-called fireproof double iron door was situated. A large quantity of combustible materials was then piled up against the two doors—iron and wood—and set on fire. After a time, the double iron door began to yield and to warp, so that the flames came through to the other side, and the heat radiated was so intense that the bystanders could not approach within ten paces of it, and for all fireproof purposes these double iron doors proved to be useless. Not so the wooden door lined with the slag-wool. Though it was subjected to precisely the same amount of heat, it was found on the off-side to be comparatively cool, so much so, that anyone could place and retain their hands on it, and when the fire had burnt out, it was found that the first thickness of wood had been burnt through to the slag-wool, and had disappeared, but that here further progress had been arrested. An even more conclusive series of tests has been conducted by W. H. Stanger, C.E., of the Broadway, Westminster. He exposed rolled iron joists, five inches deep, protected by slag-wool, and a mixture of slag-wool and plaster of Paris, termed by the inventors "Salamander Compound," to the fierce heat of a specially constructed furnace for 7½ hours, the temperature which at the end of the first hour's firing was 1,660° Fahrenheit, as shown by a Murrie's pyrometer, rose before the second hour to 2,000° and remained at this figure or one still higher until the close of the experiment. The highest recorded temperature at the abutment was 64°, and the loaded beam was deflected only $\frac{3}{8}$ of an inch. Similar beams protected by concrete and by Doulton-Pitt's tiles gave way in two hours and three and a quarter hours respectively. The beam encased in slag wool was for all practical purposes uninjured, though this test was probably more severe than anything likely to occur in an actual conflagration. The joists had each a load of 30 cwt. of pig iron distributed over a bearing of eight feet. An important property of the slag wool in the case of fire is its power of absorption, rendering it capable of holding water to the extent almost of its own volume. Thus, when water is pumped into a burning building, instead of running through into the foundation and being wasted as in the case of ordinary iron and concrete construction, the water is held by the slag-wool as by a vast sponge, and will, owing to the surrounding heat evolve steam sufficient in itself to extinguish the flames or at any rate to powerfully assist in so doing. Regarded in this light, the slag wool felted into wire netting provides us with an admirable material for fire-curtains for theatres, being sufficiently flexible to coil away above or below the stage, and being at once both extremely light and sound-proof as well as fire-proof.

The slag wool is, moreover, an antiseptic, and this property taken in conjunction with its great porosity seems to render it specially applicable for medical purposes. It has already been used for cholera belts for foreign climates, and for chest protectors, &c.

At an early stage of their attempts to utilise slag, it occurred to Mr. Wood and to several other experimenters, arguing from the resemblance in composition between this material and Portland cement, that it might be possible to produce from slag a cement of this character, and when Mr. Wood had succeeded in preparing slag-sand, he made many attempts to produce from it a cement by the further addition of lime. It is evident that if the percentage of the lime in Cleveland slag be doubled, we shall obtain a proportion between the lime and the silica similar to that found in a good specimen of Portland cement.

Even before the invention of the slag-sand, attempts were made to produce a clinker approximating to the composition of cement clinker by adding chalk or limestone in sufficient quantity to slag, grinding these substances to a fine powder, and subsequently calcining the mixture. None of these processes, however, as practised by Mr. Wood, Mr. Gjers, or Mr. F. Ransome, proved commercially successful. In conjunction with Mr. Bodmer, Mr. Wood also experimented with a mixture of slag-sand, lime, gypsum, and oxides of iron, which were simply ground together to powder, but here again no good results ensued. The first really successful attempts to prepare a sound hydraulic cement from slag were conducted in Germany by Messrs. Bosse and Walter, whose patents for this country are worked by the "Improved Cement Company," of 41, Eastcheap, under the management of Mr. E. Larsen. Upwards of two years ago I carefully examined this process, and made and tested many samples of the cement. Some of the briquettes prepared in May, 1887, I have brought with me to-day. I am thus enabled to speak of this particular method of slag utilisation from personal experience, and I believe it to be one of considerable value. The production of cements from slags on the Continent has already made great progress, and many large factories are now in working order producing thousands of tons of the cement weekly. Here in England the process has not attracted the attention it seems to me to deserve, and the cement is, I believe, at present only being manufactured in one locality, namely, at the Skinningrove Ironworks, near Saltburn.

I may preface my account of the preparation of slag cement by reminding you that slag has a very bad name with cement-users, as it was undoubtedly at one time largely employed as an adulterant. It so closely resembles Portland cement in colour, composition, and even in specific gravity, that its presence along with the cement is very difficult to detect; and in Germany, where the cement-makers have a very powerful association, and where a uniform system of testing Portland cement has been adopted, very stringent rules have been drawn up to exclude cements which have mixed with them a percentage of slag from being classed as Portland cement. While speaking of specific gravities, I may mention that the specific gravity of good Portland cement is about 3·09 and of annealed slag, 3·00, while crushed slag sand has a specific gravity of about 2·71, this diminished density being due doubtless to its porosity.

The process of manufacturing the improved cement is one of extreme simplicity. Selected slag is run into water so as to obtain slag-sand. This sand is carefully dried in order to eliminate all traces of moisture. To accomplish this the wet slag-sand, which will contain nearly its own weight of water, is first ground under edge runners. In this way the greater part of the water is removed, and the pasty mass is then spread on suitable drying plates to complete the desiccation. The dried slag is next ground under mill-stones to a fine powder and sifted to exclude coarse particles. Freshly burned pure or fat lime is slaked so as to secure its complete hydration, and the slaked lime is carefully screened. 75 per cent. of the dried and ground slag-sand is then weighed and mixed with 25 per cent of slaked lime, and the mixture is introduced into a machine of special construction. This machine, the invention of Mr. Luther, a German engineer, is termed the "Homogenizer." Its purpose is not only to stamp the materials to an extremely fine powder, but also at the same time to effect their intimate admixture. It is a hollow drum, which may be of various dimensions, depending upon the amount to be treated at each charge. The interior circumference is lined with fluted cast iron plates, and in this drum a number of small cast iron balls, varying in diameter from 1½in. to 1in. are placed. The mixture of slag and lime is introduced into the machine through a hollow trunnion, by a worm feeding apparatus at one end, and when a full charge has been added, the cylinder is caused to revolve slowly, with the result that the materials are pounded and reduced to an extremely fine state of subdivision, and very perfectly mixed. After the machine has been in motion from one to two hours, the cement is finished, and it is then only necessary to open a door by means of an automatic arrangement which permits the powder to escape, but retains the balls on a grating. A spout in the bottom of the casing enables the cement to be drawn off into sacks or casks; it is then at once ready for the market. This is the entire process, and it will be evident that it is one which, from its extreme simplicity, is capable of being carried on with a minimum of skilled labour. The plant involved is not costly, and the area needed for the factory is relatively small. A recent French writer estimates the entire cost of works and plant for an annual output of 6,000 tons (say 20 tons of cement per diem) at £6,000, which estimate includes an engine of 150 horse-power and all the requisite buildings. The point which chiefly requires to be noticed here is the extremely fine grinding secured by the use of the homogenizer. The powder produced, as tested at the Berlin Government Testing Station, left the following residues on sifting:—On a sieve of 32,250 meshes per square inch (nearly 180 meshes per linear inch), 10 per cent.; and on a sieve of 5,800 meshes per square inch (about 76 meshes linear), only 1·8 per cent. It was, therefore, in a far more finely divided state than any sample of Portland placed on the market, and the successful production of slag cement involves this very fine grinding. Mr. Wood informs me that it was on this account that all former experimenters had failed. It was impossible to secure from any previous machine such an impalpable powder as it produced in the homogenizer. The influence of fine grinding on the chemical action of slag is one of vast importance. Slag in the lump is very feebly acted upon by water, but when it is pounded extremely fine in an agate mortar, a large per-centage of soluble lime and other bases, which have probably been merely surrounded by a thin film of silicate, comes into play. I shall show you how great is the need for this extremely fine grinding from some carefully conducted tests at Choindez:—

Meshes per sq. inch.	Residues.			Age in Days.	1 to 3 Sand.		
	A.	B.	C.		A.	B.	C.
5,806	7 1	0·5	0·0	...	...	...	...
16,128	16·1	2·0	0·5	7	131	227	341
32,257	28·9	18·0	8·4	28	220	419	537

Here A B and C are the same quality of cement ground in different ways. Whereas A quality left a residue of 28·9 on a fine lawn, the C quality left but 8·4 per cent. residue. The cement C was about 2½ times as strong as A. Here the sample A was ground as fine as possible by means of millstones; sample B was passed through the homogenizer, and sample C was passed a second time through the machine, and was in an extremely finely-divided condition. Portland cement, when exposed to treatment in the homogenizer, is vastly improved, especially as respects its sand capacity; but strange to say, it is but slightly improved—nay, it sometimes loses—in tensile strength under the "neat" test.

A few words may here be necessary on the subject of cement testing. You are doubtless well aware of the fact that until recently it has been the practice in this country to test cements "neat," or without admixture with sand. This test is one which in many respects fails to bring out the best qualities of a cement, and German writers were not slow to argue that, in order to judge of the true value of any sample of cement, it was of the utmost importance to test it in the form of a mortar. The German societies interested in the manufacture and use of Portland cement met at Berlin in 1877, and adopted a uniform system of tests in a standard machine of improved construction.

The German rules were from time to time modified, but in their main features they retain their original form. The cement must be ground so fine that, when passed through a sieve of 5,806 meshes to the square inch (76 linear), the residue shall not exceed 20 per cent. (As a matter of fact, this residue in a good German cement at the present time never exceeds 4 per cent.) The cement is to be made up in a specified way with three parts of standard sand, and after remaining one day in air and twenty-eight days in water, it must show a tensile strength equivalent to 142·2 lbs. per square inch. In Austria the strength is still higher, viz. 170·7lb. per square inch. As a check, an eight-day test is also demanded. Tested in accordance with these regulations, the best slag cements leave Portland far in the rear. I have taken from Mr. Grant's work on Portland Cement the figures relating to one of the best English cements there given, tested both neat and with sand. Beneath are the best results obtained with German cement at the official testing station at Berlin in the year ending 1887. It will at once be evident that the finely ground German cement leaves the English Portland far in the rear. On the same diagram are the results obtained with cements made from various English, French, and German slags which distance all the figures I have been able to find for Portland. These figures have been kindly supplied to me by Mr. Larsen, and they are perfectly trustworthy. In some experiments I carried through, and in which, after being present at the manufacture of the cement I tested it myself in my own way, I obtained far better results than I have ever got in the tests with sand from Portland. Some of my briquettes, made two years ago, are here, but unfortunately the clips of the German machine will not fit briquettes of the English pattern, so that we cannot break them. The following were my results:—in lbs. per square inch.—

	7 Days.	28 Days.
Neat	422	471
3 Sand Standard, 20–30	205	201

A sample of this same cement officially tested at Berlin gave in—

	7 Days.	28 Days.
Neat	646	692
With 3 Sand	427	509

A fair general result with slag cement may be assumed to be with 3 of standard sand, 250lb. in 7 days and 350lb. in 28 days. These cements rapidly attain their maximum tensile strength, and do not go on, as would Portland, gradually improving for twelve months. A curious result obtained from many good samples of slag cement is that the test neat is no better than the test with sand. That is to say, that the cement will bind three times its weight of standard sand into as good a mortar as the pure cement will yield.

The chemistry of the action of cements made from slag, though it is not in accordance with some of the theories which have been propounded to explain the cause of the induration of Portland cement, is sufficiently intelligible. At a very high temperature in the blast furnace (that of complete fusion) compound silicates of lime and alumina, with small quantities of metallic and alkaline silicates are produced. These silicates are devoid almost entirely of cementitious properties, that is to say that, when reduced mechanically to a very fine state of subdivision, there is very little tendency among the particles of the powder to form fresh chemical compounds in the presence of water. The energetic action of certain cements depends no doubt either partially or entirely upon the formation of hydrated silicates, which rapidly solidify the water used in making the mortar and are said to set. In all samples of Portland cement which I have examined there is a certain proportion of free or uncombined lime. This lime may either have been present in excess of the requirements of the acids extant in the mixture, or it may have become mechanically entangled in, or coated with, the vitreous or semi-vitreous silicates formed in the kiln. It is difficult to arrive at the exact proportion of this free lime —judging from the composition of the slag cement, it is probably larger than chemists have hitherto thought possible. When the

Portland cement has been thoroughly "purged" as it is termed—*e.g.*, exposed to the atmosphere —nearly all this free lime, or the accessible portion of it, has become air-slaked, leaving, however, no doubt a small proportion of caustic or quick lime still protected from the access of moisture by its siliceous envelope.

What takes place when water is added to "gauge" the cement would seem to be a partial decomposition of silicates (here those of the slag) and a mutual reaction between these sparingly soluble silicates and the hydrate of lime with which they are intimately mixed. You will remember that all the 25 per cent. of added lime in the case of the slag cement has been first carefully slaked. This lime can therefore undergo no further chemical change when water is added. The slag has but little free lime, and of itself shows little or no cement action with water; the mutual reaction of the slag silicates and the calcium hydrate must therefore of necessity be due to a partial decomposition of the slag and the immediate formation of fresh compounds of silica, lime, and alumina, which new compounds are not only capable of induration, but which in the act of setting are able to unite very considerable quantities of aggregates in the form of mortar and concrete.

If my view of this action of the silicates is correct, it would seem either that in the case of ordinary Portland cement, the lime is present in dangerous abundance, or that, in the case of the slag cement, owing to the extreme temperature attained in the blast furnace, different combinations of lime, alumina, and silica are obtained, which, however, are of an equally fixed and stable character to those produced from similar mixtures at lower temperatures in the cement kiln.

The behaviour of the mechanical mixture of slaked lime and very finely divided inert silicate of lime and alumina, which constitutes the slag cement, throws much doubt upon those theories of cement action which imply that in Portland cement the induration is caused by the hydration of ready-formed silicates, or that certain silicates produced by the action of heat in the kiln are under the influence of water recombined or altered into hydrated double silicates, since it is evident that in this new cement considerable quantities of hitherto uncombined lime are united to the silicates of alumina and other bases present in the slag. The exact nature of this action has, I regret to say, not yet been satisfactorily explained. It may be of some use in elucidating this problem, if we remember that the physical properties of the slag, apart from its chemical composition, would seem to play a very important part in this cement action. Thus the same sample of slag allowed to cool slowly has few or no hydraulic properties. The physical tension which exists between the ultimate atoms of the slag may be greatly altered by sudden or rapid cooling, as by immersion into water, or the use of the air or steam jet, and it is only the slag thus treated which can successfully be employed for cement making.

I have dealt at such length with these general considerations that I must pass very quickly over the other matters of interest concerning this cement. The specific gravity is very low, only 2·73, as determined by Mr. Stead. Thus, a cubic foot weighs only about 75 lbs., or the bushel about 90 lbs., as compared with 112 to 115 lbs. for a good dense Portland. The time occupied in setting is comparatively long. Few really good slag cements set in under four to five hours. For the purpose of storage this cement compares well with Portland. If freely exposed to the air the lime gradually attracts the carbonic acid and does this more rapidly than does Portland; thus in four days a thin layer of slag cement gained about 5 per cent of carbonic acid, the amount of the gas taken up in the same time by Portland cement being only 1 per cent. The slag cement does not, however, deteriorate greatly in tensile strength by long exposure, as the following experiment will prove:—A sample was tested with sand and gave at seven days 254 lbs., and at 28 days 340 lbs.; after being kept for 15 months the same tests gave 243 lbs. and 321 lbs. respectively, or a loss in strength of about 5 per cent. For works in water, owing to the closeness of its particles, the cement would appear to be particularly well adapted. It is now being produced, as already stated, at Skinningrove Iron Works near Saltburn, and it is being employed there in the construction of a sea-wall, mixed with crushed slag for concrete. Used in this way it attains great hardness in sea-water, and makes excellent work. Its introduction into this country has hitherto been beset by very great difficulties, caused partly by the unscientific methods of cement testing now practised, and partly by the opposition of cement manufacturers. Abroad it has been, as we have seen, largely employed, and excellent cements are being made from slag at a score of places on the Continent. In Germany, used alone or mixed with Portland cement, it is held in great favour.

For paving purposes, I do not think it will compare with or take the place of Portland, as owing to its want of density it does not give the same hard surface as that cement. Its great cheapness and marvellous sand-binding powers ought, however, to enable it in time to supplant the inferior qualities of mortar made from fat or pure limes, and it is in this direction that I anticipate for the slag cement a great demand in this country.

The last derivation of slag I have to bring under your notice is not a blast furnace slag, but one produced in steel manufacture.

In speaking of blast furnace slag I pointed out that, except in a very finely divided condition, it is sparingly soluble in water. From the point of view of the farmer, slag of the ordinary description has, as you will see on glancing at the analyses I have brought together, very few ingredients likely to be of value to him. The chief fertilising elements required by the agriculturist are the nitrogen compounds and ammonia, phosphoric acid and potash. Now although these substances are not present to any great extent in common slag, there is a recent process of steel manufacture in the course of which considerable quantities of slags are obtained, some of which are extremely rich in phosphoric acid. In order to understand this it will be necessary very briefly to examine the Bessemer system of steel-making and the modification of the same introduced by Messrs. Gilchrist and Thomas in 1879. You are doubtless aware that the process of producing steel invented by Bessemer consisted in burning out all the carbon and silicon in cast-iron or selected pig-iron, by passing a blast of atmospheric air through the molten metal, and then adding such a quantity of a pure cast-iron to the wrought-iron thus prepared, as was necessary to furnish carbon enough to convert the whole mass into steel; the molten metal was then at once run out and cast into ingots. The operation takes place in a pear-shaped iron retort lined with fire-brick called a Bessemer "converter," and this vessel is made of sufficient size to deal with charges of several tons of steel at a time, the transformation of the iron into steel occupying only some twenty minutes. One of the most difficult impurities to expel in certain kinds of pig-iron is the phosphorus, and a very small percentage of phosphoric acid in steel has the effect of rendering it brittle. The extraction of the phosphorus from the raw material was under the above process attended with very serious difficulties, and had the effect naturally of rendering steel a costly article because only the purer and better qualities of pig-iron could be employed. By the introduction however of the Thomas-Gilchrist process in 1879 the obstacles in the way of removing the phosphorus were to a large extent overcome, and even very inferior samples of iron (such as those from the Cleveland district) could be used for steel-making. This so-called "basic" process consists essentially of a change in the method of forming the internal walls or lining of the converter. Formerly, as we have seen, the lining was of fire-brick, a substance rich in silica. This was the "acid" process; but under the new patent this lining was replaced by one of dolomitic lime, and lime was also added to the molten metal —hence the "basic" process. The operation varies but little in other respects from that of Bessemer. An air-blast is injected, the impurities are burnt off or oxidised, and the phosphoric acid combines with the lime and rises mixed with certain silicates to the surface of the vessel as a scum or slag. The converter is so mounted as to be capable of being rocked or tilted, and the molten slag can be poured off from the surface of the steel.

In this way the so-called "Thomas Slag" or "basic slag" is obtained. For some years after the introduction of this process the slag was regarded as a mere bye-product of no value, and was permitted to accumulate on the waste heaps. In 1883, however, it occurred to some of the German chemists that a substance so rich as is this slag in phosphates ought to possess some commercial value as a fertiliser, and experiments were made to test this matter practically. You will see from the analyses I have given of two samples of "basic slag" that the phosphoric acid varies from about 14 to 19 per cent. These slags were produced in the treatment of pig iron which contained respectively 1·75 and 2·5 per cent of phosphorus. It is, however, quite possible to obtain these basic slags with upwards of 30 per cent. of phosphoric acid, the richness in this constituent depending partly on the quantity of lime used and partly on the amount of phosphorus present in the cast iron. Attempts have been made in Germany, during the last few years, to obtain a slag richer in phosphates than that obtained heretofore, and Professor Scheibler has devised and patented a process for this purpose. He slightly modifies the usual plan of proceeding, and instead of treat-

TABLE I.—COMPOSITION OF VARIOUS DESCRIPTIONS OF SLAG.

Analyses of Slag.	Middles-brough.	Bilbao.	Saulnes.	Choindez.	Hartz-burg.	Belgium.	Glass.
Lime (CaO.)	32·75	47·30	47·20	45·11	48·59	44·75	12·50
Silica	30·00	32·90	31·65	26·88	30·72	32·51	69·00
Alumina	28·00	13·25	17·00	24·12	16·40	13·91	7·40
Iron (FeO.)	0·75	0·46	0·65	0·44	0·03	0·48	—
Magnesia	5·25	1·37	1·36	1·09	1·28	2·20	—
Sulphide of lime	1·90	3·42	—	1 86	2·16	4·90	—
Manganese	0·60	1·13	0·85	0·50	traces	0·60	soda.
Residue	0·75	0·17	1·29	—	0·42	0·65	11·10
Total	100·00	100·00	100·00	100·00	100·00	100·00	100·00

TABLE II.—ANALYSES OF SUBSTANCES OBTAINED FROM SLAG.

Analyses of Slags.	Chilled Slag.	Slag Sand.	Slag Mortar.	Slag Brick.	Slag Cement.	Portland Cement.	Thomas Slag No. 1.	Thomas Slag No. 2.
Lime (CaO)..........	29·44	29·76	29·40	22·31	39·68	61·07	41·58	47·34
Silica	36·50	36·56	25·15	21·60	24·34	21·70	7·38	5·76
Alumina	22·95	22·98	21·80	19·85	8·74	8·60	2·57	1·43
Protoxide of iron	0·06	0·06	1·44	4·00	0·27	—	13·62	12·72
,, ,, manganese	0·32	0·31	0·26	0·21	0·23	—	3·79	3·43
Peroxide of iron.....	—	—	1·66	8·80	0·14	2·25	8·54	2·07
Magnesia...........	5·94	5·93	5·10	4·36	6·59	1·17	6·14	6·01
Potash	0·59	0·60	0·53	0·50	0·28	0·75	—	—
Soda	0·36	0·33	0·36	0·32	0·44	0·42	sulphide of lime	
Sulphur	sulphide of lime (CaS)		1·00	1·19	0·93	—	0·54	0·91
Sulphuric acid	3·89	3·51	1·25	1·54	0·25	1·93	0·12	trace
Phosphoric ,, ...	—	—	0·01	0·02	carbonate of lime	—	14·36	19·19
Carbonic ,, ...	—	—	2·60	3·00	4·07	0·80	—	—
Water, &c.	—	—	9·50	12·00	4·70	1·26	1·29	1·19
Total......	100·05	100·04	100·06	99·70	100·66	99·95	99·93	100·05

TABLE III.—TENSILE STRENGTH OF CEMENTS EXPRESSED IN LBS. PER SQUARE INCH.

Derivation of slags made into cements.	How kept.	1 : 3 Sand.				Neat cement.			
		7 Days.	28 Days.	3 Months.	12 Months.	7 Days	28 Days.	3 Months.	12 Months.
South Wales	Water	280	314	430	500	582	697	—	—
,, ...	Air	230	327	—	—	—	—	—	—
Middlesbrough ..	Water	328	470	482	375	405	416	—	—
,, ..	Air	253	263	430	529	—	—	—	—
Skinningrove ..	Water	320	440	447	483	506	564	—	—
,, ..	Air	247	322	—	—	—	—	—	—
Brunswick	Water	350	420	—	—	410	523	—	—
Osnabrück	,, ...	214	420	—	—	—	—	—	—
Nancy	,, ...	405	630	725	—	350	410	440	—
,, ...	Air	420	495	—	—	—	—	—	—
,, ...	Sea water ...	380	510	600	—	400	430	510	—
Portland cement.	Water	—	62	132	161	558	674	815	825
German ,,	,, ...	274	364	—	—	—	—	—	—

ing the pig iron with an excess of lime in the first instance, he adds a quantity insufficient to complete the total dephosphorisation of the iron. The resulting slag is very rich in phosphoric acid, and correspondingly poor in iron. The charge is then again treated with fresh lime, which completes the removal of the phosphorus. This same lime may be used over again. Slag obtained under Scheibler's process forms a much more concentrated phosphatic manure than the ordinary slag, and is commercially known as "Patent Phosphate Meal." In Germany, where these slag manures are already widely known, the annual consumption has now reached 300,000 tons. Our English farmers have been somewhat slow to recognise the merit of this valuable substance, but Messrs. H. and E. Albert, of 17, Gracechurch-street, to whom I am indebted for much interesting information on this subject, are now in a position to supply the slag in a very finely ground state, and large mills have been erected near Middlesbrough, at the works of the North-Eastern Steel Company. In Germany, the introduction of this cheap fertiliser has progressed with astonishing rapidity, and has exceeded the total available native production of the slag, which has to be exported there from this country and from Austria to the extent of 100,000 tons annually, so that what is here neglected is being exported to Germany to enrich a foreign soil. The average price of a ton of finely ground phosphate in Kent or Essex at the present time, as quoted to me by Messrs. Albert, is 45s., in bags per full truck-load. This is very little more than 1s. per unit of phosphate of lime, as they guarantee the manure to contain from 37 to 42 per cent. of calcic phosphate. The phosphoric acid in the slag is combined in a very unusual way with the lime, and forms what chemists have termed a tetra-basic phosphate. As it occurs in nature as a mineral "phosphorite," and in bones, it is as the so-called tribasic phosphate, or three equivalents of the base, calcium, to one of the acid. The aim of the chemist, in order to render the substance more soluble, and more readily adapted to plant food, is to expel two equivalents of the base, replacing them by water, and to obtain what is known as super-phosphate, or a mono-basic phosphate.

When applied to the land the super-phosphate is acted upon by the various earthy acids and is speedily converted into a bibasic or precipitated phosphate, and owing to its solubility the super-phosphate is distributed far better through the soil than a phosphate in any other condition. It has been found that the tetrabasic phosphate of the slag in reality resembles a precipitated phosphate, it is no longer insoluble like the tribasic salt, but is, when in an extremely fine state of division, very rapidly dissolved in water or weak acid. I need not bring under your notice here, for time will not permit, the various practical and laboratory experiments whereby the behaviour of these phosphates has been tested, and compared with the superphosphates of commerce, but I may state generally that whereas the superphosphate is more rapid in its action, the slag phosphate would seem to be more lasting, and that the after-effects of its application can be traced far more strongly than in the case of an equivalent dressing of a super-phosphate. I, here, use the word equivalent to denote equal in price. The ground Thomas slag is about half the cost of the superphosphate, and the farmer can therefore apply two tons of the slag where he would use one ton of the more costly manure. Professor Wrightson, who has carefully investigated this subject, recommends a dressing of this fertiliser at the rate of from 6 to 10 cwt. per acre. I hope that English farmers will shortly become convinced of the value of this really first-class material, as it seems sad that we should be importing phosphates from America in large quantities, and exporting a good home-made phosphate to the Continent.

I have thus brought before you some of the chief recent methods of using slag, and, though I have far from exhausted the subject, I trust I may have been able to prove that this material has been somewhat unjustly despised, and that in many directions, and for a large variety of useful purposes, it has a great future in prospect.

DISCUSSION.

The CHAIRMAN said it was quite unnecessary to dwell on the importance of this subject or the ability with which it had been treated. Any one who was acquainted with the district round Swansea where, literally, mountains of slag were accumulated, would feel that great faith was required in any process by which these mountains could be removed and utilised. The reference to Luther's pulveriser reminded him that at the birthplace of another Luther, at Eisleben, in Saxony, the roads were paved with slag blocks cooled very slowly and devitrified; slag was also used extensively in New York, and was being widely used for ballast on railways. The extreme difficulty of grinding and pulverising this material had led the German Government to offer a prize of £500 some time ago for the best arrangement which would prevent the immense wear and tear which it had hitherto caused in the machinery, but although many machines were exhibited, none took the prize, which was divided between two. He thought the quantity of basic slag used for manure was a little understated. It was very interesting also to remember the great number of artificial minerals which had been found in slag. These could now be seen illustrated in the magnificent collection of the late Dr. Percy, which was now placed in the Museum of the Royal School of Mines. If he had to do penance, he thought he should prefer a hair shirt to one formed of slag wool, for notwithstanding its silky texture, he should be afraid of some of the fine particles penetrating the skin. In conclusion, he would remark that slag had also been used in art work, some of the glassy kinds having been cast into forms of great beauty.

Sir I. LOWTHIAN BELL, Bart., F.R.S., as a large producer of slag, said it was satisfactory to know that whatever uses it might be applied to, there was not much danger of the raw material running short. He made something like half a million tons a year, and should be glad to enter into a beneficial contract with anyone who would show him how to use it. He thought Mr. Redgrave had rather over-estimated the quantity of iron made in this country, which he did not think had ever reached quite ten million tons. The English farmer seemed to be somewhat blamed for not making more use of the phosphoric acid in basic slag; but his experience had not been altogether favourable to it. Twenty years ago he pointed out that the phosphorus in iron was very valuable matter in the wrong place; that it injured the Cleveland iron to the extent of a million sterling a year, and that the phosphorus itself was worth another million. As soon as the North-Eastern Company began to grind this basic slag—and, in fact, before that he had been in communication with the German manufacturers—he commenced a series of experiments with it. Amongst other misfortunes which had befallen him, was that of being an English farmer farming his own land, and in the hope of making that occupation profitable, or, at any rate, of reducing the loss upon it, he had tried the virtues of phosphoric slag; but he was bound to say that on his land, excepting in the case of roots, he found no advantage from it. The slag was laid on properly ground and the crops were weighed, and neither in the first nor in any succeeding year, this being five years ago, was there the slightest perceptible difference on the grass land. On the other hand, he knew that in other places better results had been obtained, and it was undoubtedly useful for turnips.

Mr. G. J. SNELUS, F.R.S., said he used a large quantity of blast-furnace slag, eighteen years ago, by grinding it up into the form of mortar, and after being moulded into bricks, it was used under very trying circumstances. He lined a large water-cooling course with these bricks, and they were intact to this day, though some ordinary bricks used at the same time had crumbled very much. He also built a large wall along the side of a river, with the same material moulded into blocks about half a ton weight, and a lot of loose slag was thrown into the bed of the river, and the cobble stones embedded in it at the foot of the wall; they were there to this day, and the slag remained as hard as any granite. For a few years past he had been endeavouring, in conjunction with Mr. Gibb, to utilise it for making cement, and he was now connected with a works which was using 100 tons of blast-furnace slag every week in this way; the only reason they did not use three times as much was because they could not get it granulated. He had in his hand some tests made with briquettes of this cement, which were as follows:—

	7 days old. per sq. in.	28 days old. per sq. in.	3 months. per sq. in.
No. 1	420 lbs.	470 lbs.	600 lbs.
,, 2	370 ,,	560 ,,	650 ,,
,, 3	390 ,,	530 ,,	720 ,,

It was evident, therefore, that slag could be made into thoroughly sound cement, resembling Portland cement in every respect. There was an objection to the German process, that being only dried it sometimes contained moisture, which made it gradually age, and some failures might be attributed to that cause. In the process his firm worked under, the granulated slag was calcined, which got rid of all trace of moisture, and also had another important advantage. All blast-furnace slag, especially when they were making hematite iron, contained a considerable quantity of sulphur in the form of calcium sulphide, which became gradually oxidised to calcium sulphate with the evolution of sulphuretted hydrogen. He used some of this cement years ago for the outside of his house, and for a long time they could not tell what it was which produced the unpleasant smell whenever the weather was damp; but after a long investigation it was discovered that this cement contained calcium sulphide, which was gradually being oxidised. The process of calcination got rid of that difficulty, converting the sulphide into sulphate of lime, which was an improvement, being the basis of alabaster. There was no doubt a time coming when this hitherto waste material would become very valuable. They had been sending away this cement now for two years, and had had very excellent reports of it. Again, with regard to road-making, he was connected with another works which was making a thousand tons a week, and it was all going at about 1s. 6d. a ton for road-making material. It was broken up with a crusher, and taken away as fast as it was made. This was a very common use, but probably when all the roads were made good the slag would not be wanted. The use of it to replace Portland cement, however, would not be easily exhausted. Basic slag was quite different from blast-furnace slag, in that it contained phosphorus, and he was sorry to hear that Sir Lowthian Bell had not been so successful with it as some: but he thought they had sufficient evidence from all parts of the world of its value, to feel assured that in future none of it would be wasted. He had had many inquiries for it lately, showing that it was in great demand.

Sir LOWTHIAN BELL said he did not question its value, only it did not seem to suit his particular land.

Mr. PERCY GILCHRIST said the importance of the blast-furnace slag question would be seen in looking at the figures, which showed that about 10,000,000 tons were made annually, and he had been surprised to find how much more was used for the humble purpose of road-making than for anything else, about one million out of ten; and if people would only turn their attention to making it rather more suitable for this purpose there would be a still greater demand for it. As regards basic slag, he found that last year there were about 600,000 tons made, containing, roughly, 17 per cent. of phosphoric acid, and 60 per cent. of lime. Of course, it was not a suitable fertiliser for all soils, calcareous ones for instance, but for sour, peaty, and clay soils it was of great value, as was shown by the fact that all the 600,000 tons were sold at from 20s. to 30s. a ton at the works. It was interesting to note that the phosphoric acid was combined with the lime in a different way to what had been found before, and instead of being a tri-basic phosphate it was a tetra-phosphate, which instead of being insoluble in water was readily soluble, and thus only required very fine grinding in order to be utilised by plants. At first the attempt was made to treat it by various chemical methods, the same as superphosphate, but it was not until it occurred to some of the German chemists that the simplest plan would be the best, that it became successful. Scheibler's method of forming two kinds of slag, first a rich one and then a poor one, was not in general practice; it was made, under the ordinary process, to contain 17 per cent. phosphate, and was simply ground up and used in fine powder.

Mr. E. LARSEN said Mr. Redgrave had dealt so fully with the German process of cement-making that there was not much to add. It had been brought before the principal iron masters of England, but for some reasons he did not understand they had not taken it up. The only one who had introduced it on a practical scale was Mr. Hutchinson, who had also used it in construction.

Mr. HUTCHINSON asked if the tests quoted by Mr. Snelus were of neat cement, or with sand?

Mr. SNELUS said they were all neat cement, but tests with sand were very similar.

Mr. HUTCHINSON said he had been manufacturing this cement for upwards of three years, and had used almost all he had made in the construction of the harbour works at Skinningrove. For this purpose the slag should be granulated in the hot condition, not cooled in the usual way. Cement made from ordinary cooled slag had no cementitious quality at all; and briquettes made from such slag, with the ordinary per-centage of lime added, would hardly bear the weight of the beam, without any load at all. These experiments were verified by continental manufacturers, and details were given in the Iron and Steel Institute proceedings for 1866. They commenced very much in the way described by Mr. Walter in his German specification, but they found the difficulty already mentioned as to getting rid of the moisture. After experimenting for some time, he adopted a method, which had been patented, of drying the slag by the initial heat contained in it, running it into a very shallow bath of water, into which a jet of steam played, and drove it into the house broken up and perfectly dry, ready for grinding. The next difficulty was in getting machinery to grind it, and that was still a difficulty. After using up several machines they got a Carter's disintegrator, and broke down the steel arms in less than a week, and then got a Globe mill. But the cost of grinding was so serious that they were obliged to abandon it, and he thought they would have to come back to the German method of grinding by stones, in the same manner as Portland cement. The preparation of slag sand by this means gave a gelatinous silica which helped very much in giving the setting property to cement. He had some tests with him which showed on the average of five, after twenty-eight days—the proportion being three parts of sand to one of cement—475 lbs. to the square inch. Another one, after four months, 480 lbs.; another one (twenty-eight days), 391 lbs.; another one (four months), 421 lbs. He had taken out an average of tests over a considerable period, and found the increase of strength in six months was somewhat under 100 lbs.; there was a gradual improvement up to six months, and beyond that a slight improvement, but not much. Briquettes at eighteen months were only slightly superior to those at six months. The harbour works he had referred to were the largest yet made entirely of slag cement. There was a wall about thirty feet in height from the foundation, which was about seven feet below low water mark, and a pier which was now about 620 feet from the shore. The concrete was so hard that when a bulge occurred on the face of the wall, which he ordered to be taken off, there was the greatest difficulty in doing it even with specially hardened steel bars, and it was found that the matrix did not come away, but pieces of solid slag chipped off in connection with the matrix. The cement was mixed in large tubs at the end of the pier, and put down in a very liquid condition on to the rock at the bottom, from which the sand had been removed by a pump constructed for the purpose, and the concrete there formed a bed about four or five feet thick, on which a timber staging was erected, and the wall built up. During the late heavy storms they lost about twenty cubic yards, but except that, they had not lost a single length of concrete, nor any great depth of it, during the whole progress of the work. One peculiarity of this concrete was its extreme toughness, which would render it valuable for fortifications; hammering did not break it, but made a dent as if it were lead.

Mr. T. GIBB thought the utilisation of slag altogether depended not merely on fine grinding but on pounding it well in the process. Luther's pulveriser was a very old machine, and could be no more called an invention than the steam-engine which worked it. The use of the ball drum was the most important feature of any recent adaptation of slag to cement making, for equally fine grinding in millstones would not have the same effect. If Mr. Hutchinson would turn his attention to that machine, his difficulties in grinding would probably cease. These, however, were only mechanical details; the more important point was that referred to by Mr. Snelus. The addition of lime to blast-furnace slag in cement-making was only a source of weakness, but the calcination, converting the sulphide of calcium into sulphate of lime, abandoning altogether the use of hydrated lime, would bring the product much more into correspondence with Portland cement, not only in appearance but in properties. The Improved Cement Company, as he understood, did not follow out Messrs. Bosse and Walter's specification, which was to make a cement similar in composition to Portland cement; 75 per cent. of Cleveland slag and 25 of slaked lime gave a very different composition, and in point of fact it was perfectly useless as a hydraulic cement, though it might be a somewhat improved mortar.

Mr. STEWART said he had a good deal of experience of silicate cotton and its adaptation to various purposes. They had heard how it could be used for scientific purposes, and it could also be used for filtration, for medical purposes, with disinfectants, and in other ways. He was then wearing a cholera belt made of it, and when suffering from rheumatism he tried it as a liver-pad. The intention was to carry it still farther, and he believed that in addition to the many uses to which it had been put, it would be utilised in a great variety of ways.

Mr. J. S. JEANS said the utilisation of blast-furnace slag appeared to have been carried further on the Continent than here, and the German chemists were the first to discover or apply the valuable properties of basic slag. At a comparatively early stage one of those gentlemen called on him and said he wanted to purchase all the basic slag he could get, but he understood that the price he offered was about 2s. 6d. per ton at the works, and they had just heard that it was now worth from 20s. to 30s. Slag was largely used in Cleveland by the Tees Conservancy Commissioners for the purpose of a breakwater, and he thought it would be a good thing if it could be used for the streets of London, though probably the weight and cost of transport would be objectionable, and he had heard that it would be too slippery.

Mr. WALTER F. REID thought the proportion of sulphuric acid given in the Table was much too high for good cement; and in one case it would amount to 3 per cent. of sulphate of lime in the cement when mixed with water, which would be a dangerous amount. The chief difficulty was the sulphur. If Mr. Snelus had got over that difficulty he could make a good cement. An interesting experiment could be made by heating a piece of sulphate of lime to a bright red heat, and then placing it in a jar of water and leaving it for a few months; the whole surface would become covered with beautiful crystals; he had some which were nearly an inch in length. That process took place to a still greater extent in slag, or any substance into which it entered when exposed to water. Sulphide of calcium, when moistened, certainly gave off sulphuretted hydrogen, and he believed great difficulties had been experienced from the use of slag-wool from this cause, when used inside houses in any place where the damp could get at it. If put behind a fire-place or round steam-pipes where it was kept warm and dry, it might be safe. For medical purposes, or where it came in contact with the skin, his experience was that it caused great irritation and produced a rash, probably from fine particles getting into the pores. The shot produced in making the slag wool had been attempted to be utilised for millinery purposes when silvered over; but it was found that the silvered shot turned black, no doubt from the evolution of sulphuretted hydrogen, and the idea had to be abandoned. Good cement could be made from slag if it were passed through a furnace a second time, but not otherwise. He found in agreat number of experiments that cement made according to the Walter process did not stand weather so well as Portland cement, either neat or mixed with sand, and that agreed with the observation that had been made, that it would be good for fortifications, because it was tough and did not crack. That was on account of its great porosity. When water came in contact with it, it would be absorbed, and when it froze it would be liable to exfoliate. The late Mr. Grant made a number of experiments with all kinds of Portland cement, and his experience with slag cement was that there was great initial strength, but it diminished after a time. There was one cement referred to in the Tables which would be absolutely dangerous; at three months it showed a strength af 480 lbs., and in twelve months it had decreased to 375, which showed that concrete made of it would crumble away in a few years. Good Portland cement would always increase in strength. The weight per bushel was sometimes considered very important, but it depended entirely on the fineness of the grinding; coarsely ground it was heavy. If slag could be toughened in any way, it would be very valuable for railway sleepers.

Mr. STEWART protested against the idea that slag-wool was irritating to the skin, and said he had lived for twenty years in a house where it was used, and there was never any smell.

Mr. LARSEN said Portland cement would increase in strength up to eighteen months, and then would invariably diminish.

Mr. REDGRAVE, in reply, said he had taken the make of iron from the Board of Trade returns, but no doubt Sir Lowthian Bell's figures were more likely to be accurate. The question of calcium sulphide present was of very small importance; he had had a very large experience in this matter, and up to 3 per cent. it produced no injury at all. Its effect was simply to render the Portland cement more slow setting. The analysis containing sulphuric acid, to which Mr. Reid took exception, was of a very good Portland cement, taken from Mr. Grant's book, which tested very well. His experience was that Portland cement increased in strength for a certain period, but after two years it invariably began to fall off slightly. That was shown in the testing of concrete; it expanded slightly for a certain period and then began to shrink, and with large blocks this was very noticeable. Portland cement reached its maximum strength in about two years, and after that it would go back as much as 10 per cent. in five years. That was proved by Mr. Grant's experiments.

The CHAIRMAN then moved a vote of thanks to Mr. Redgrave, which concluded the proceedings.

Correspondence.

LONDON SEWERAGE AND SEWAGE.

Mr. R. F. GRANTHAM, M.Inst.C.E., writes that he considers the suggestions contained in Sir Robert Rawlinson's paper most useful at the present time, as they point to a comprehensive way of dealing once and for all with the sewage of London. Many schemes, more or less defined, for disposing of the sewage, such as chemical treatment, irrigation, and filtration, have been suggested, but they all miss the mark in failing to realise the enormous volume of the liquid to be dealt with, a fact which places London in a different category from that of any other place in the world. First, with regard to chemical treatment, the ultimate success of the experiment now being tried on the metropolitan sewage seems doubtful, inasmuch as similar processes have been tried and have failed over and over again, with comparatively insignificant quantities of sewage, and it also seems doubtful, according to experience up to the present time, whether any chemical process can effectually deal with the sewage of London, except at very great annual cost and the production of an enormous quantity of sludge. Secondly, with regard to irrigation, many have spoken in favour of it, and Dr. Carpenter went so far as to say that there are thousands of acres round London, not worth 5s. per acre, calling out for sewage. Now, Essex is the only county in which it would be practicable to dispose of London sewage by irrigation, and the first question to determine is the quantity of land required. Having underdrained considerable areas of land in various parts of the county, and being at the present moment engaged in draining a town in it, he has become intimately acquainted with the varying character of the subsoils over a large part, and therefore is able to form an idea of the quantity of sewage the land generally is capable of absorbing. Much of the subsoil is stiff clay, and the ordinary rainfall, which is by no means excessive, percolates in wet seasons very slowly through it, even after it has been closely underdrained. It would be impossible to find a large area, say of 10,000 acres, in a ring-fence, without meeting with a good deal of this subsoil which would not bear the application of a large quantity of sewage. The 150,000,000 gallons a day ordinarily discharged from the London sewers, if distributed over 10,000 acres, must be absorbed at the rate of 15,000 gallons per acre, or equivalent to a rainfall of nearly $\frac{3}{4}$ inch every twenty-four hours, continued at all times and in all seasons, beyond that which naturally falls on the land; and this makes no allowance for increase, or for storm-water, or for the inclusion of the sewage of towns in the Lea valley, as suggested by Sir Robert Rawlinson. This, in his opinion, is the largest quantity of sewage that can be applied continuously on average agricultural land in Essex, in whatever manner the surface may be prepared, and therefore 10,000 acres would be the minimum area of land that would be required at once. Seeing that such an area must include houses and country seats, the price of such land would probably be nearer £50 per acre than 5s., if it were known to be required for the disposal of London sewage. With regard to filtration, he is intimately acquainted with Canvey Island as engineer to the Canvey Island Commissioners for the repair of the sea walls, and as the subsoil is for the most part alluvial deposit, he is inclined to think, with great deference to the opinions of others on the subject, that it is not suitable for the purpose, nor is the situation favourable, owing to its proximity to the increasing watering-place, Southend. Seeing, then, the difficulties which surround these various modes of treatment, he thinks that ultimately there will be no other course than to conduct the sewage to the Maplin Sands in some such manner as that proposed by Sir Robert Rawlinson. It will, however, be only fair to watch the results of the experiments undertaken by the London County Council for a given time. With regard to one or two points of detail in Sir Robert Rawlinson's scheme, he would like to make a few remarks. The plan of an open channel, or new river with level reaches from point to point, seems to him as one certain to be productive of nuisance in dry hot weather, and those reaches must become places of deposit which would have to be cleared out. Again the suggestion that farmers along the line of conduit would take the sewage is open to doubt. To be properly distributed, the surface of the land must be prepared, and as the Essex-marshes are fine grazing grounds, and much of the arable land is good corn-growing land, he thinks that the majority of the Essex farmers—and he knows several along the route—would decline the trouble and labour involved. The statement (page 78) that "in warm summer time 1,000,000 gallons of sewage may be utilised on one acre, &c," appears to be a misprint, as no ordinary agricultural land would take as much as 1-10th of that quantity in one day. The sewage, therefore, must be disposed of in Maplin Sands, and perhaps Mr. Bailey Denton's plan of filtration would be applicable there. But entire reclamation of the sands need not be attempted. Embankments gradually formed so as to promote accretion as practised on other parts of the coast would, with the assistance of the deposit from the sewage, eventually convert the sands into a fertile piece of land. The effluent would be discharged into the West Swin Channel, which varies from seven to twelve fathoms deep at the margin of the sands, without a risk of nuisance or injury to anyone. Such a scheme properly carried out would free the Thames from all risk of pollution, and would put London in the foremost place as regards the disposal of its sewage as it now is with respect to its general system of sewers.

Mr. CRAWFORD BARLOW writes:—The Report of the Royal Commission in 1884, divided the various plans for treating the metropolitan sewage into six:—

I.—On land, on the broad irrigation principle.

II.—On land, by filtration (otherwise called the intermittent system).

III.—Chemically.

IV.—Chemically, with subsequent application to land.

V.—Outfall of sewers to be removed further down the river.

VI.—Outfall of sewers to be removed to the sea.

With regard to the opinion of the Commission on these plans, they may be briefly summarised as follows:—

I.—Would be a matter of great difficulty on account of the enormous quantity of land, and consequent cost and opposition.

II.—Would be applicable to the metropolitan sewage.

III.—Would not effectively purify the effluent.

IV.—Offers one of the most feasible means of solving the difficulty.

V.—Is not expedient.

VI.—Not to be recommended.

Sir Robert Rawlinson's scheme is, therefore, one (No. VI.) which was not recommended by that important Commission. With regard to the Metropolitan Board of Works' scheme of chemically treating the sewage and carrying the sludge by barges to sea, the opinion of the Commission was, that this process (No. III.) alone would not effectually purify the effluent. The proper course is to adopt the plan recommended by the Commission, or some modification of it, so long as their recommendations are kept in view. With this object the sewage should be treated slightly at the outfalls, so as to get rid of the grosser elements, and then the liquid should be pumped up to an elevation of, say, 60 feet, and conducted by main channels and branches along the contours, and so be capable of being discharged at many points on the land below that elevation. This elevation enables the sewage to be discharged over a very large area; the western boundary of this area may be taken as a line running almost due north of the northern outfall up to the 50 feet contour; the northern boundary will be the 50 feet contour, a very irregular outline extending from due north of the outfall to the village of Leigh, opposite the eastern extremity of Canvey Island, where the contour comes close to the river bank, and the southern boundary will be the river bank; the area comprised within these boundaries is 80 square miles, equivalent to 51,000 acres. In convenient spots within this area sufficient land should be bought for treating the liquid sewage by the intermittent filtration process; according to the evidence before the above-named Commission, the sewage of 670 people can be effectively treated in this manner on one acre, so that the quantity of land to be acquired for dealing with the whole population at present, and for about ten years ahead, would be 7,500 acres. Besides this, provision should be made for laying on the sewage direct from the channels to those farms which would take it; and as these would increase (as experience showed, from the evidence of Berlin, Paris, &c., it would) the value of the sewage on land, this area of 80 square miles with the above arrangement, would be found sufficient to deal with the London sewage for many years to come. With regard to the objections to sewage farms, such as polluting water, smells, &c., there is no more objection on these heads than at present from the manures, natural and artificial, which are found to be used on any farm. The main consideration is the cost, and this will be no more than that of the conduit to the sea, but with this advantage that there will be a chance of some revenue coming in from the sewage farms, which will go towards the annual expenses.

Mr. Isaac Shone writes that he has made calculations to find whether Sir Robert Rawlinson's statements with regard to the hydraulic head necessary to convey the sewage 46 miles, as he proposes, are correct. By these calculations, which are based on Kutter's hydraulic formulæ, it would appear that the head suggested by Sir Robert Rawlinson would be sufficient, and that a circular sewer 20 ft. 9 in. in diameter would suffice to carry the sewage of 5,500,000 people when it was running half full, at the period of maximum flow. If the conduit were to be rectangular in section, like a canal, it would have to be 55 feet wide to carry the sewage of 5,500,000 people, when running 4 feet deep at the period of maximum flow, with a fall of 23 feet in 46 miles. This canal would suffice for the sewage proper only, reckoning the sewage discharges of each person at 30 gallons per head per day. But the rainfall, as already stated, would augment the maximum volume of sewage proper, it may be, from two to tenfold. But, accepting these figures for our guidance, and reckoning the population of London 31 years hence to be 7,000,000 (as estimated by Mr. R. Price Williams, M.Inst.C.E.), then the quantity of the sewage and rainfall discharges would be equal to 420,000,000 gallons per day in wet weather. This enormous volume would amount during the period of maximum flow to about 525,000 gallons per minute, and this would require a canal or conduit 80 feet in width, the sewage running 6 feet in depth, and laid with a fall of 23 feet in 46 miles. The estimate of first cost, which Sir Robert Rawlinson adopts for the purposes of his proposals, and which estimate was entered into for a project proposed 33 years ago, is totally inadequate. His estimate of the pumping power and annual cost would also be totally inadequate. At the same time, looking at the enormous prospective growth of London, and at its enormous resources, what it can do, for a rate of 1d. in the £ for instance, the London County Council should give the proposal to acquire Canvey Island for outfall purposes their most serious consideration. Canvey Island is, roughly speaking, about halfway between Barking and the points of outfall suggested in Sir Robert Rawlinson's paper. If the sewage of London can be comparatively successfully treated, as it is alleged it can be, at Crossness and Barking—which, however, appeared doubtful, judging from the statements of Dr. Dupré—the acquirement of Canvey Island ought certainly to enable the London County Council to treat the sewage ultimately successfully, before passing it, partly into the sea, and partly on to the land in the manner suggested by Sir Robert Rawlinson and Mr. John Phillips. The public have not yet sufficiently appreciated the

International process and the A B C process of treating and clarifying sewage. A great future awaits Mr. W. Webster's electrolysis process of treating sewage, though this process had not yet been tried on a large scale. At Canvey Island there would be room for each of the above processes and others to be tried on a large scale, and there would be space enough to dispose of comparatively large volumes of sewage by irrigation, and the whole of the sewage sludge on the plan suggested by Mr. E. Bailey Denton and Lieutenant-Colonel Jones.

Dr. THUDICHUM writes:—Sir Robert Rawlinson says, "The underground railway has, in some degree, been allowed to usurp the site and to cripple the low-level intercepting sewer in its dimensions and capacity." To this alleged crippling he ascribes the necessity for "the (large) storm-overflows, causing pollution of the Thames [from this small (*sic*) intercepting sewer." This is an absolutely baseless imputation directed against the late Board and its engineers. The sewer was designed and executed in due proportion to the entire plan, and does its work admirably. No reasonably intercepting sewer could have held, or conducted, the storm-sewage (we have had on occasions more than 3 inches of rain in a few hours in London), and no reasonable number of pumps at Abbey Mills could have raised, or could raise the storm-sewage, even allowing that it could have been conducted there. In short, the overflows as safety valves are quite unavoidable; no two main sewers could be made large enough to carry the storm-water of 117 square miles of streets and houses. The diversion of storm-water from the sewers which receive house drains is no doubt an important consideration; it may be partially effected in suitable places. Page 68, col. 2, Sir Robert requires "special provisions to remove (divert ?) spring and other subsoil water from the sewers to the river." This is, as regards London, an impracticable proposition, as I could easily show by geological details did space permit. Therefore, to censure what cannot be altered, and to blame authorities and engineers for doing what cannot be done otherwise, appears to me utterly wrong and useless. Sir R. Rawlinson's general attacks upon the late Board are rather unintelligibly expressed, as p. 71, from col. 1, line 26, to col. 2, line 30. But the climax of Sir Robert's invective against the late Board is reached on p. 79, col. 1, line 15, where this body is charged with "having blundered over the Thames purification question," and with having "handed over" "abortive works," which would "cost the County Council no less than a million sterling to get rid of." This must be entirely and unreservedly contradicted. It is a mere unfounded statement; there has been no blundering, and there has been no abortive works; still less will the works extant, in any case, require "a million sterling to get rid of," whatever that may mean. The late Metropolitan Board of Works did all that was reasonably suggested, not only as temporary expedients, but also as radical remedies. Thus the Board used chloride of lime to deodorise the Thames. But experience taught the objection, whereupon the Board used manganate and permanganate with perfect success, and without drawback, except that at first of the price of the reagent, which was £40 a ton. Upon the advice of their chemical officer, the Board established works and produced the reagent themselves, whereupon the price came down to £14, and ultimately below £8 per ton. Therefore this action of Board and chemist saved the ratepayers large sums of money, and the Board ceased to manufacture from the moment that the trade did regularly supply the required material at the new price. On the subject of precipitants, the chemist of the Board, Mr. Dibdin, made exhaustive experiments, and wrote a monograph, which was read before the Institute of Civil Engineers, discussed on several nights, and printed in the "Transactions." Then would have been the time for the promulgation of Sir Robert Rawlinson's objections; now they are not only useless but injurious. The Metropolitan Board of Works also caused experiments to be made on the compression of the sludge in filter presses, on drying of the sludge on beds of ashes and cinders, on burning it in kilns; these processes were found either too expensive or impracticable on the necessary scale, and in view of the ultimate solution found by the engineers—namely, the carrying of the sludge to sea by steamers—wasteful and unnecessary. Therefore the late Metropolitan Board of Works did all they could reasonably be expected to do, and followed a regular course. For all the science concerned in the matter had to be made by the process of evolution, by appreciation of necessity, by thought, by experiment, by the experience of others, and all had to be done consistently with the lowest possible expenditure. The late Metropolitan Board of Works were our representatives, and if they did not come up to Sir R. Rawlinson's ideal, he must blame us, the electors of Vestries, out of whose midst the members of the Board were elected. The strangest feat of Sir Robert is his attempt to whitewash and obliterate his report, according to which the allegation that the London sewage obstructed the River Thames "utterly failed." But this attempt has equally failed, as also the appeal to preserve the silver Thames and its silver sheen. By all means let us preserve it, and begin with keeping out the needily-clarified sewage of the towns and villages of the Thames valley. Then our drinking water will be purer and more wholesome, and our sewage less of a scapegoat for the sinners up the valley. I am quite ready to discuss Sir R. Rawlinson's scheme, point by point, from the engineering, chemical, hygienic, agricultural, and financial point of view. It does not bear investigation from any one of them.

Mr. F. G. WORTH writes:—Sending sewage to sea was considered a grave error in Paris, Berlin, and Dantzig. It is stated by many and competent authorities that the sea will not retain sewage; this could, perhaps, be tested by emptying the present sludge vessels continuously at the outfall proposed by Sir Robert Rawlinson. I know of more than one sewage farm which is an absolute failure. Surely the London County Council could experiment on, say 1,000 acres, to ascertain if London crude sewage is adaptable or not.

Mr. HUGO WOLLHEIM writes to point out that Lord Bramwell's Commission stated, in their final report, that they could not recommend either of the schemes for the removal of the outfalls to the sea, and that as that Commission clearly defined the proper course to be pursued in the case of the London sewage, the County Council will no doubt feel themselves in duty bound to carry out these recommendations. As the Commissioners did not recommend any particular process of precipitation, the County Council are free to decide, after a fair trial, upon the most efficacious one available.

Mr. GEORGE W. BREMNER writes to recommend the use of compressed air by forcing it into the base of the sewage tanks for the purpose of aerating the sewage; and he also suggests the utilisation of the heavy flow of the London sewage as an economical motor for driving the air compressors.

CORRECTION.—In the Table of death-rate (p. 144, col. 2), the average of Edinburgh should be 22·529, instead of 29·529.

EAST INDIA RECORDS.

The reading of Mr. F. C. Danvers's paper, which may be taken as a sort of sequel to Sir George Birdwood's special report on the early proceedings of the East India Company, marks the progress of the modern desire to study history first hand whenever practicable. My object just now is to remind those who heard or may read Mr. Danvers's paper that that there are two or three pioneers in this movement whose names should not be forgotten. The most important of these is, in my mind, the Rev. Philip Anderson, chaplain of Calaba, who, so long ago as 1854, published his "The English in Western India," which has long been prized by the denizens of the Presidency as a clear and consecutive narrative of the early history of Surat and Bombay, and has furnished the text for much that has since been written on the subject. Anderson (who died early, much regretted by his contempoiaries) may be regarded as the first to recognise, from the popular and literary side, the special value of the official records, whence, under many difficulties, he mainly drew the materials for his book. The rest would be chiefly derived from the narrative of Dr. John Fryer, who published, in 1682, a comprehensive and a very realistic description of the island of Bombay and its inhabitants of that period. Next after Anderson in the work of rescuing and popularising old Indian records was the late Rev. James Long—unless (I write under correction) he had been preceded by Mr. T. T. Wheeler from Madras. Mr. Long, early in the sixties, published extracts from the oldest *Calcutta Gazettes*, many of which were very picturesque, and revived interest in records of the time, thereby stimulating the movement towards that practical phase it has now assumed. It should be noted that the two series of (official) "Selections from Government Records" printed, if not published, by the Bombay authorities, covered a period going back into the forties, and are always available at the Bombay Secretariat, probably also at the Library of the India-office. The next series of independent publications of tihs kind is that by Mr. James Douglas, a bank manager, who, with much industry and enthusiasm, has sought out and written upon many of the forgotten manuscripts and neglected publications bearing on the middle period of the history of Western India. Many of these papers have appeared in the dailies, and must have been collected and published in "The Book of Bombay." It was printed at the *Bombay Gazette* office; but as no London publisher's name is given, the work is not easy to procure. The efforts of these volunteer builders and self-dependent explorers may be compared to the lower tiers of the "scaffolding" of which Mr. Danvers spoke. The later extracts from the Bombay records by Professor Forrest, being produced under official direction and support, will pertain rather to that inner and authorised monumental work spoken of by Mr. Danvers, and in which he at present is foreman, if not a "master builder."

W. MARTIN WOOD.

Brook-green.
January 27th.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

FEBRUARY 5.—ARTHUR PAGET, "High-speed Knitting and Weaving without Weft." W. ANDERSON, Vice-President of the Society, will preside.

FOREIGN AND COLONIAL SECTION.

Tuesday afternoons, at Five o'clock:—

FEBRUARY 18.—J. HENNIKER HEATON, M.P., "Ocean Penny Postage and Cheap Telegraph Communication between England and all Parts of the Empire and America."

INDIAN SECTION.

Friday afternoons, at Five o'clock:—

FEBRUARY 7.—Dr. SCHLICH, "The Utility of Forests and the Study of Forestry."

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock :—

FEBRUARY 11.—W. R. LETHABY, "Cast Iron and its Treatment for Artistic Purposes."

CANTOR LECTURES.

Monday evenings, at Eight o'clock :—

Professor SILVANUS P. THOMPSON, D.Sc., M.I.E.E., "The Electro-magnet." Four Lectures.

LECTURE III.—FEBRUARY 3.—*Special Designs.*—Various forms and their uses. Electro-magnets for quickest action; for longest range; for maximum traction; for minimum weight; for alternate currents; for series work; for parallel work.

POPULAR LECTURES.

Saturday afternoons, at Three o'clock :—

Professor VIVIAN LEWES, "The Atmosphere." Four Lectures.

March 8, 15, 22, 29.

ADDITIONAL LECTURES.

Thursday evenings, at Eight o'clock :—

LEWIS F. DAY, "Design applied to Wood-Carving." Three Lectures.

May 1, 8, 15.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, FEB. 3...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Prof. Silvanus P. Thompson, "The Electro-magnet." (Lecture III.)

Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.

Engineers, Westminster Town-hall, S.W., 7½ p.m.

Chemical Industry (London Section), Burlington-house, W., 8 p.m. 1. Mr. A. H. Allen, "Metallic Compounds of the Phenols." 2. Mr. Watson Smith, "New Method of Hardening Steel for Projectiles." 3. Mr. Losanitch, "Bromanil."

British Architects, 9, Conduit-street, W., 8 p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

Victoria Institute, 1, Adelphi-terrace, W.C., 8 p.m. Mr. H. B. Guppy, "The Dispersal of Plants, as Illustrated by the Flora of the Keeling or Cocos Islands."

London Institution, Finsbury-circus, E.C., 5 p.m. Rev. Prof. J. P. Mahaffy, "A Visit to Mount Athos."

TUESDAY, FEB. 4...Royal Institution, Albemarle-street, W., 3 p.m. Dr. G. J. Romanes, "Before and After Darwin.—The Post-Darwinian Period." (Lecture III.)

Central Chamber of Agriculture (at the HOUSE OF THE SOCIETY OF ARTS), 11 a.m.

Civil Engineers, 25, Great George-street, S.W., Mr. W. H. Wheeler, "Bars at the Mouths of Tidal Estuaries."

Pathological, 20, Hanover-square, W., 8½ p.m.

Biblical Archæology, 9, Conduit-street, W., 8 p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Mr. W. K. Parker, "The Morphology of a Reptilian Bird (*Opisthocomus cristatus*)." 2. Mr. A. D. Bartlett, "Observations on Wolves, Jackals, Dogs, and Foxes." 3. Mr. G. E. Dobson, "A Synopsis of the Genera of the Family Soricidæ."

WEDNESDAY, FEB. 5...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. Arthur Paget, "High-speed Knitting and Weaving without Weft."

Geological, Burlington-house, W., 8 p.m. 1. Messrs. Grenville A. J. Cole and J. W. Gregory, "The Variolitic Rocks of Mont Genèvre." 2. Prof. J. W. Judd, "The Propylites of the Western Isles of Scotland, and their relation to the Andesites and Diorites of the same district."

Inventors' Institute, 27, Chancery-lane, W.C., 8 p.m. 1. Discussion on the paper, "Lessons Deducible from Recent Fires." 2. Descriptions of inventions for minimising the dangers of fires.

Institute of Bankers, in the Theatre, London Institution, Finsbury-square, E.C., 7 p.m.

Entomological, 11, Chandos-street, W., 7 p.m.

Archæological Association, 32, Sackville-street, W., 8 p.m.

Obstetrical, 53, Berners-street, W., 8 p.m. Annual General Meeting.

THURSDAY, FEB. 6...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Mr. C. B. Clarke, "The Stamens and Setæ of Scirpeæ." 2. Mr. J. Ball, "The Flora of Patagonia." 3. Exhibitions :—(i.) Certain Seaweed-covered Crabs. and (ii.) Pitchers of *Nepenthes Mastersiana*, by Prof. Stewart.

Chemical, Burlington-house, W., 8 p.m. 1. Prof. Ramsay, "The Oxides of Nitrogen." 2. Dr. Armstrong and Mr. W. P. Wynne, "Studies on the Constitution of Tri-derivatives of Naphthalene." 3. Messrs. G. G. Henderson and J. Morrow Campbell, "The Action of Chromium Oxychloride on Nitrobenzole."

London Institution, Finsbury-circus, E.C., 6 p.m, Mr. A. J. Spencer, "The Law of Buying and Selling."

Royal Institution, Albemarle-street, W., 3 p.m. Mr. E. R. Mullins, "Sculpture in Relation to the Age." (Lecture III.)

Archæological Institution, Oxford-mansions, Oxford-street, W., 4 p.m.

FRIDAY, FEB. 7...SOCIETY OF ARTS, John-street. Adelphi, W.C., 5 p.m. (Indian Section.) Dr. Schlich, "The Utility of Forests and the Study of Forestry."

United Service Inst., Whitehall-yard, S.W., 3 p.m. Lieut.-Col. A. W. White, "Range Finding; its destined effect on Tactics."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Mr. H. B. Wheatley, "The London Stage in Elizabeth's Reign."

Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. Colin P. Fowler, "Reclamation of Land on the River Tees."

Geologists' Association, University College, W.C., 7½ p m. 1. Annual Meeting. 2. Address by the President, Mr. T. V. Holmes, "Notes on the Nature of the Geological Record."

Physical, Science Schools, South Kensington, S.W., 5 p.m. 1. Annual General Meeting. 2. Prof. W. E. Ayrton and Messrs. T. Mather and W. E. Sumpner, "Galvanometers." 3. Mr. F. B. Hawes, "A Carbon Deposit in a Blake Telephone Transmitter."

SATURDAY, FEB. 8...Royal Institution, Albemarle-street, W., 3 p.m. Prof. Flower, "The Natural History of the Horse, and of its Extinct and Existing Allies." (Lecture III.)

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

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FRIDAY, FEBRUARY 7, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

Professor Silvanus P. Thompson, D.Sc., delivered the third lecture of his course on "The Electro-Magnet," on Monday evening, the 3rd inst., in which he dealt with the question of special designs.

The lectures will be printed in the *Journal* during the summer recess.

Proceedings of the Society.

NINTH ORDINARY MEETING.

Wednesday, February 5th, 1890; William Anderson, M.Inst.C.E., in the chair.

The following candidates were proposed for election as members of the Society:—

Morgan Frederick, 10, St. Edmund's-terrace, Regent's-park, N.W.
Morris, Phil. R., A.R.A., 33, St. John's-wood-road, N.W.
White, John Thomas, 11, Bedford-row, W.C.

The following candidates were balloted for and duly elected members of the Society:—

Holt, Horace Henry, 17, Parliament-street, S.W.
Reynolds, Dr. John, 369, Coldharbour-lane, Brixton, S.W.
Whitwell, William, Thornaby Iron-Works, Stockton-on-Tees, and Overdene, Saltburn-by-the-Sea.

The paper read was—

HIGH-SPEED KNITTING AND WEAVING, WITHOUT WEFT.

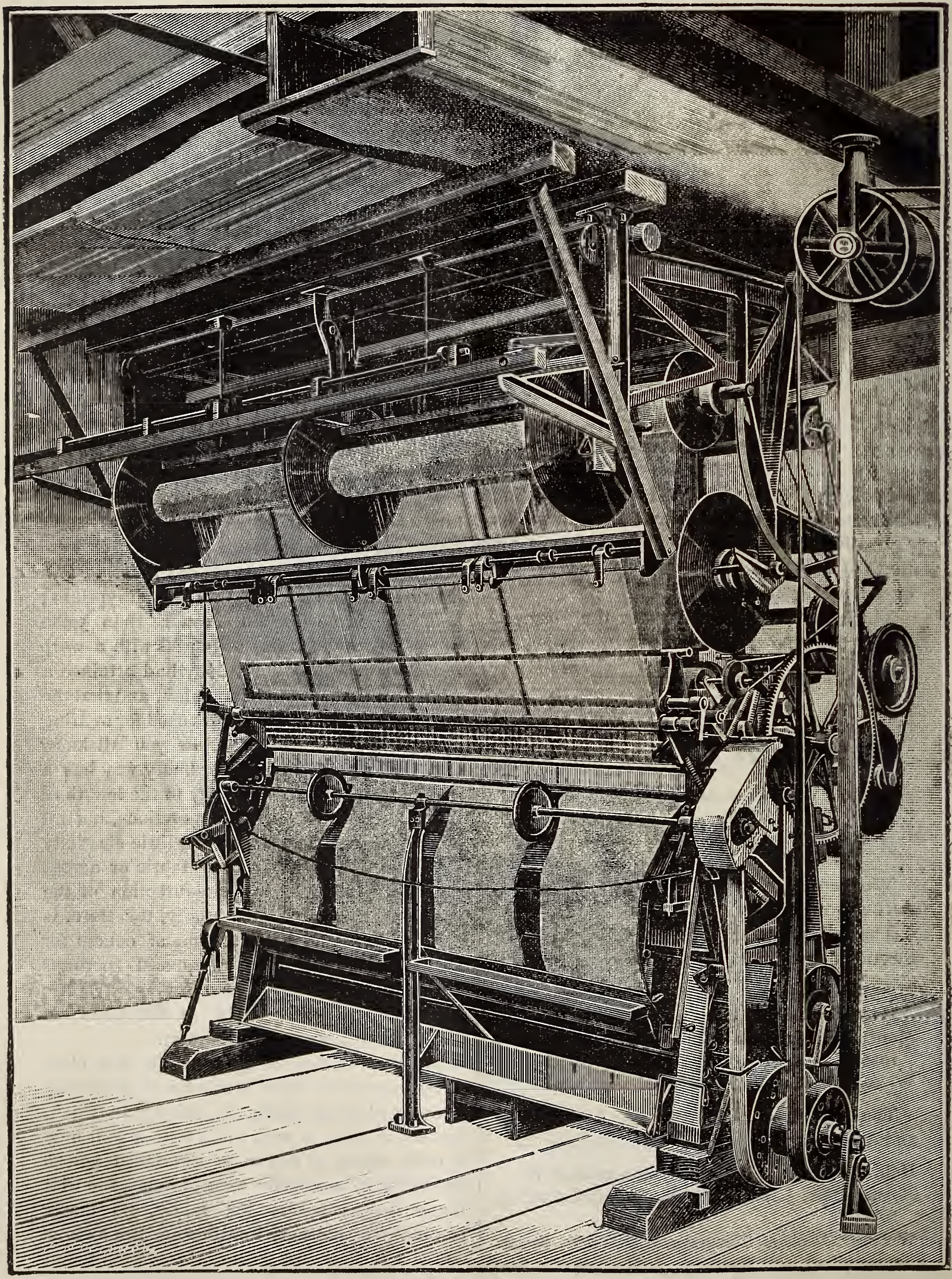
By Arthur Paget,

Vice-President of the Institution of Mechanical Engineers, M.Inst.C.E.

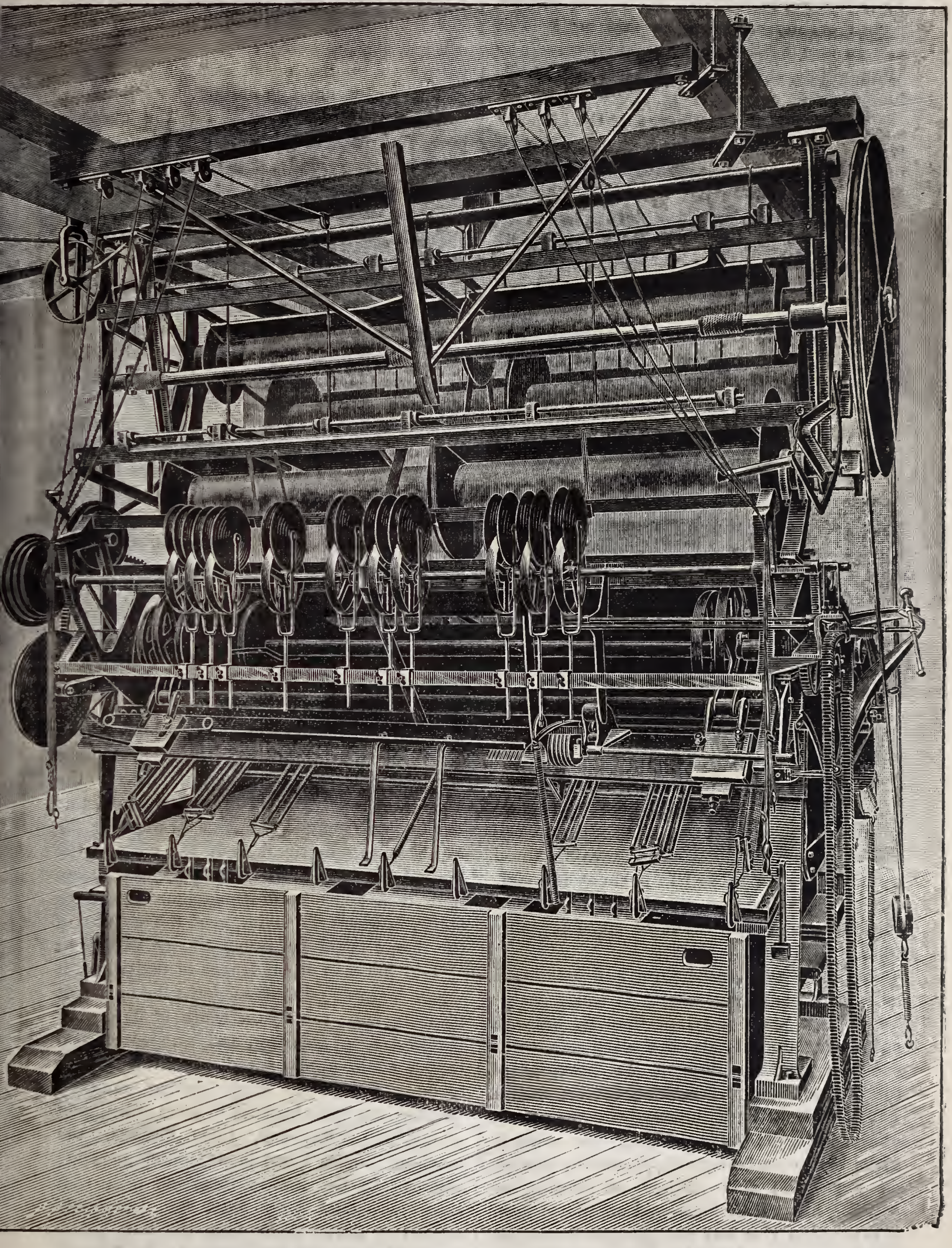
Probably in the records of any of the early races of man, one of the earliest signs of a more advanced civilisation which we find is the proof that the art or invention of weaving was in use. The first method of weaving used is always that of ordinary weaving with a warp and a weft, in which the threads of the weft cross the threads of the warp, so that each thread of the weft passes under one thread of the warp, and then over the next thread of the warp, in the manner shown in the figure (D. p. 247), and in the sample of fabric annexed. This method of weaving, there is no doubt, dates back at least as far as 5,000 years, if not more; and, as far as I know, the earliest records of such weaving are found among the Egyptians and allied races, and I am told that in some lately discovered tombs illustrations have been found of the primitive looms which were used for weaving the cere-cloths which we find around the mummies of the early Egyptians; and there is no doubt that, more than 5,000 years ago, the weaving of fabrics with a warp and a weft in the ordinary way had attained a considerable degree of perfection, and that the richness of some of the fabrics used for wearing apparel was very great. Now you all know that a cloth woven in the ordinary way has a degree of elasticity diagonally to the length of the piece of fabric in both directions, but all ordinary woven cloths have very little elasticity either the lengthways of the fabric or across the fabric, *i.e.*—either in the direction of the warp or the weft. The elasticity, therefore, is very uneven and limited, and of course for many articles of wearing apparel (perhaps more particularly for underclothing) a fabric with an elasticity equal in all directions has always been a great desideratum.

The first method of approaching this elasticity appears to have been what is generally known as knitted fabric, *i.e.*, a fabric in which, instead of using a warp and a weft, a weft only is used, which is woven or interlaced across the fabric in successive rows of loops, the weft being looped across the fabric, no doubt originally by ordinary knitting-needles as now used. I believe that no record has been found of the use of this system of producing cloths or fabrics by knitting earlier than a few

PAGET'S PATENT WARP-WEAVER AND KNITTER.



A.—Front of the Machine.



B.—Back of the Machine.

hundred years ago; and though there is no doubt that the Egyptians possessed machines for ordinary weaving, *i.e.*, looms, the earliest record of any machine for making knitted fabrics is a hand-knitting frame invented by William Lee, a curate of Calverton, in Nottinghamshire, about the year 1589.

You are probably all aware that the industry of making knitted goods, knitted from weft only, is one which has greatly increased, and even in my lifetime the increase of this industry for making knitted hosiery goods of all kinds in the districts of Leicestershire, Nottinghamshire, and Derbyshire, and more recently in Lancashire and other counties, has increased enormously.

I left Manchester to go to Loughborough to undertake the management of a hosiery manufactory in the year 1854; and to show the enormous changes in this industry from the year 1854 up to the present date, on referring to the books of my firm of that period, I find that a dozen pairs of "30 gauge hose," or stockings, which are such as a lady would wear in autumn, winter, or spring, the cost for knitting in the hand-knitting-frame (which was then the only machine that could make any class of stockings shaped to fit) was from 6s. to 6s. 6d. per dozen pairs; whereas in the power machines now made by my firm stockings slightly better than those made in the year 1854 can now be knitted complete for 1s. 10d. per dozen pairs. The highest wages paid to an intelligent, reliable woman engaged in hosiery manufacture up to the year 1854 was only from 8s. to 8s. 6d. per week of sixty hours, whereas for some years past (notwithstanding the reduction in the cost of knitting these stockings) when trade has been at all good, women have been in the habit of earning from 18s. to £1 per week of fifty-five hours work.

The third and least-known and least-used method of producing fabrics is called warp-knitting or warp-weaving, that is, knitting or weaving the threads of a warp only, without weft, and the date of the invention of the first machine for making fabrics with a warp only (that is, by knitting together a set of warp-threads without using any weft) is given by one authority as 1775, and by another as 1780, and this method of knitting or weaving has hardly increased at all—in fact, it is doubtful if it has not decreased—and its chief uses have been for making the fabric of which cotton "Berlin gloves" are made, which most of you may remember best as the white cotton gloves usually worn by the "greengrocer" who, with his gloves, has been immortalized by Dickens, Thackeray, and other writers, as being employed in the evenings as a waiter or pseudo-butler at the banquets of the middle-classes. Warp-woven fabric is also now used for the exceedingly fine, delicate fabrics of which ladies' silk gloves are made, and these gloves have given quite recently a great spur to the decaying trade of warp-weaving or knitting.

There have been many attempts to make cloths and other similar fabrics by warp-weaving, but hitherto they have not been successful for any lengthened period.

The method of shaping articles of apparel during the process of producing the fabric has hitherto been entirely confined to articles of apparel made by ordinary knitting with weft only. Lately, when making some improvements in warp-weaving or knitting machines, it occurred to me that if a warp-knitted fabric were made with an increased length of loops, the fabric would be materially increased in width. This of course is the case to a very minor degree in ordinary knitting; but you will see by the Figure (D, p. 247) that in knitting with weft only, the length of the loops lie almost exactly in the direction of the length of the fabric, and therefore the increase in the width of the fabric when the loops are lengthened is very slight; whereas, if you examine the illustration of the stitch of the warp-woven fabric, you will see that these loops lie more diagonally, and therefore, if the loops are lengthened in the warp fabric, this has a much greater tendency to increase the width of the fabric than is the case in the knitted fabric. It therefore appeared to me that if a warp knitting-machine could be made, in which the variation of the lengths of the loops could be automatically varied at certain portions of the length of the fabric, it would be quite possible to shape the fabric at pleasure (*i.e.*, to vary the width of it) during the process of weaving, and it appeared also that a much higher speed of knitting ought to be attainable by warp knitting than by knitting the weft, because in warp knitting in a machine with, say, 1,000 threads, the machine makes 1,000 loops simultaneously; whereas in the knitting-machine with weft each individual loop must be completely formed or drawn down from the weft before the next loop can be begun to be formed. These trains of thought have been, after much labour and many experiments, embodied and brought to a final successful issue, and have now been given practical life and a concrete shape in a new machine.

I will now proceed to describe the main principles of this machine for "Warp Weaving at High-speed without Weft,"* three views of which are shown at A, B, and C. In this machine there are a number of threads constituting what is known as a warp, and in the most simple of these machines these threads are wound upon a weaver's beam (which is a very long roller or reel), so that the threads can be drawn off the beam all equal in length, and each one at an equal distance from the other, exactly as in the ordinary beam, in the ordinary loom, and the problem to be solved by this machine is to take each one of these threads (say 1,000 to 2,000 threads in each machine), and to interlace or weave a loop from each thread with a loop from its neighbouring thread on each side of it. In this machine each of these threads is manipulated, or woven, or interlaced, by the immediate touch or action of three parts, which, for convenience, I will call the three primary parts.

If you will now kindly look at the figure F (p. 250) showing the primary parts which manipulate the thread, and the section of part of a Paget's Patent Warp-Weaver and Knitter, you will see that the primary parts which manipulate the thread are, first, the trough, A; second, the needle, B; and, third, the hook, C, which are shown separate and enlarged on E (p. 248). Each of the troughs, A, has a thread threaded through it, and takes this thread as it is drawn off the beam at the upper part of the machine, and guides or conducts it to each one of the row of needles, B, and there is one trough to each one of the row of needles. The cycle of movements of the machine is commenced by the row of troughs being moved so that each trough lays its thread across and over one needle; and I will now ask you to turn your attention to this model of a section of part of the machine, which is thirty-two times full size, and shows only 6 needles, 5 troughs, and 5 hooks (of the 1,000 needles, 999 troughs, and 999 hooks in the real machine). You will now see how the troughs lay their threads on the needles (G, p. 251, Fig. 1); next, the troughs having laid the thread across the needles, the row of needles then retires until the point of the "beard," or hook, of each needle passes over the thread which has been laid upon its stem (G, Fig. 2); next, the beard of each needle is pressed into the eye of the needle (*i.e.*, the groove in the upper part of the stem of the needle) by a bar (B, 13), which is called a "presser" (G, Fig. 3); next, the "presser" holds down the points of the "beards" of the needles in these grooves, while the point of the "beard" of each needle passes into and safely through the loop of the fabric which has been previously knitted, and which is hanging on the stems of the needles, (G, Fig. 4); next, the needles retire further, so that the "heads" of the needles pass a certain distance beyond the face or front of the row of hooks, C, and thus a certain length of thread is pulled by the hook of each needle against the face of each of the hooks, and drawn through each loop of the fabric which was on each needle-stem, and is thus drawn through each trough, and from the beam of warp (G, Fig. 4); next, while the "heads" of the needles are still held back behind the troughs, and behind the face of the row of hooks, the troughs are again moved sideways, one space further in the same direction as they moved before; next, the row of hooks is made to descend, so that the underside of the bend at the top of each hook presses upon each thread (G, Fig. 4); next, the needles are made to advance, and the hooks to descend, simultaneously, so that the loops already pulled by the needles against the face of the hooks will now be drawn down by the hooks, while the row of needles continues to advance to its former position; this completes the first cycle of the motions of the machine (G, Fig. 5).

Another row of loops is now commenced to be formed and interlaced with or drawn through the las woven row of loops in exactly the same way, only that the row of troughs, each of which formerly passed over the needle next to it on its right side, now passes over the needle next to it on its left side, and so lays a loop over the needle contiguous to the needle on which it laid its loops during the previous cycle of motions.

This second cycle of the motions is then completed, and the third cycle of the motions is exactly similar to the first cycle of the motions.

Thus you will see that each loop in each row of loops is looped to and thoroughly interwoven with the loop next to it on its right side in the row of loops next formed, which loop is again looped to and thoroughly interwoven with the loop on its left side in the next row of loops, and so on, and thus in this way you see

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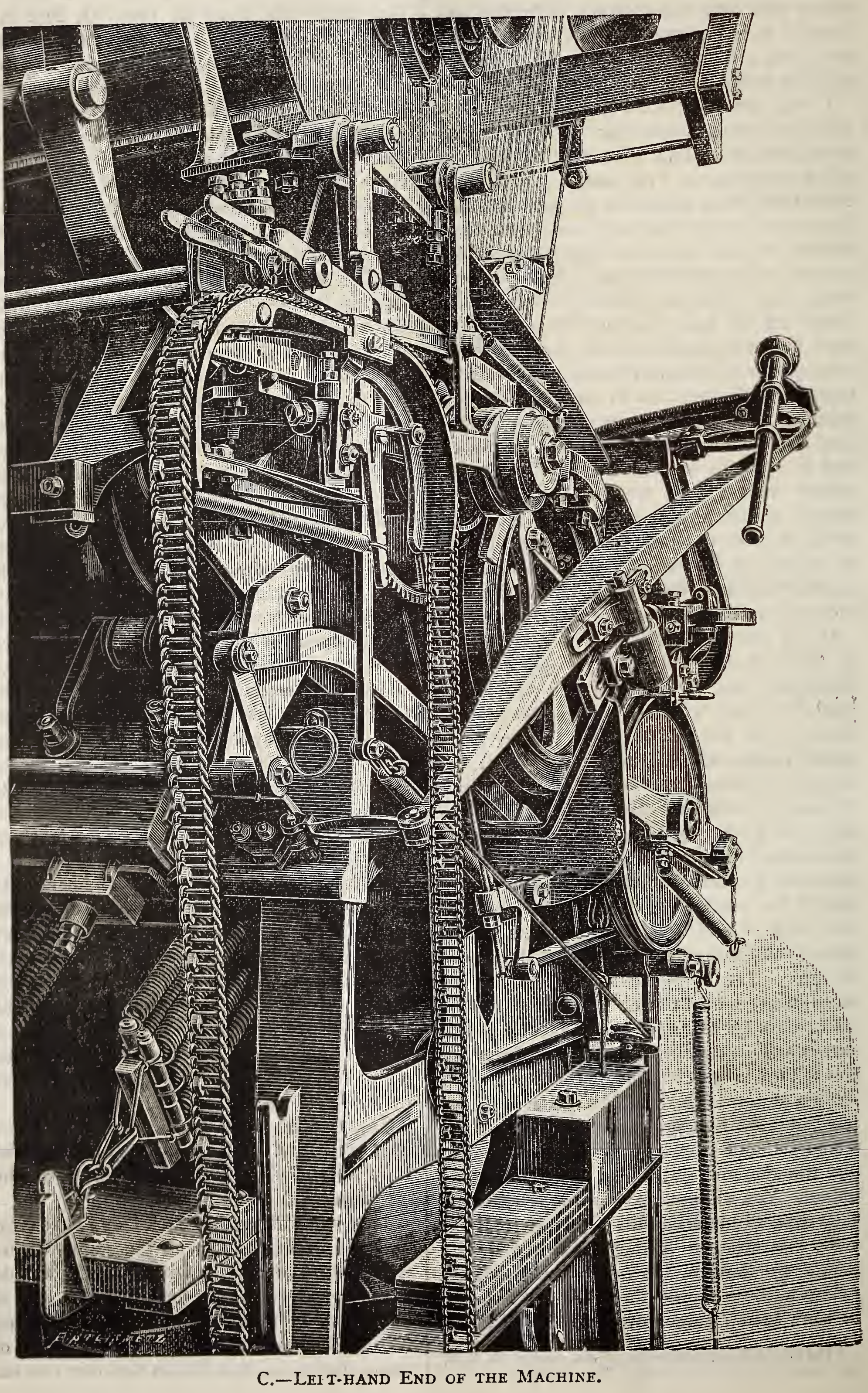
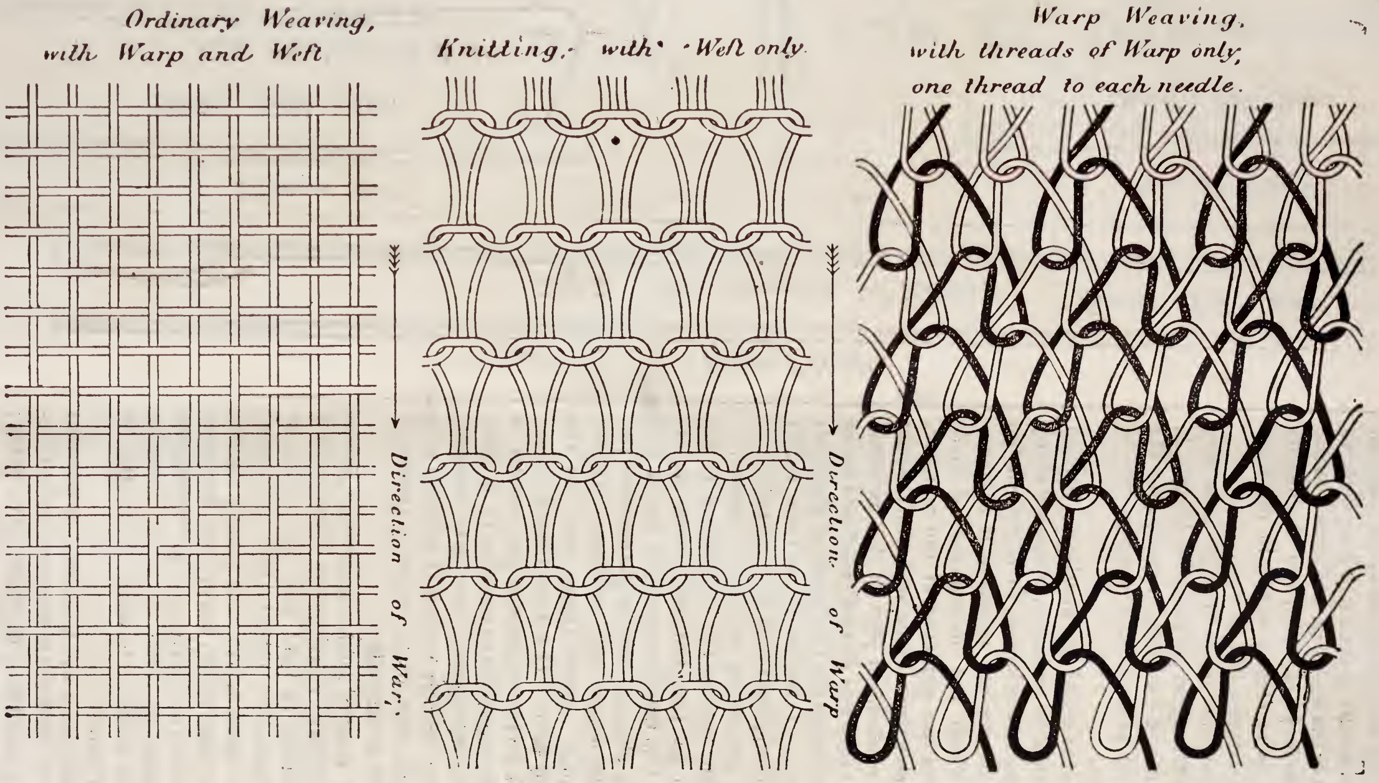
* The three full-page illustrations of the machine (A, B, C) have been kindly lent by the editor of *Engineering*.



C.—LEFT-HAND END OF THE MACHINE.



Ordinary Weaving, with Warp and Weft

Knitting: with Weft only.

Warp Weaving, with threads of Warp only, one thread to each needle.

D.—Three Methods of Weaving Yarns into Fabrics.

that a row of loops is formed by each cycle of the motions of the machine, and each loop is thoroughly connected to, interlaced with, or interwoven with the contiguous row of loops on either side of it during each following cycle of the motions of the machine, and thus a fabric is formed, the loops of which are thoroughly interwoven, as is clearly shown in the third figure in the diagram (D., p. 247).

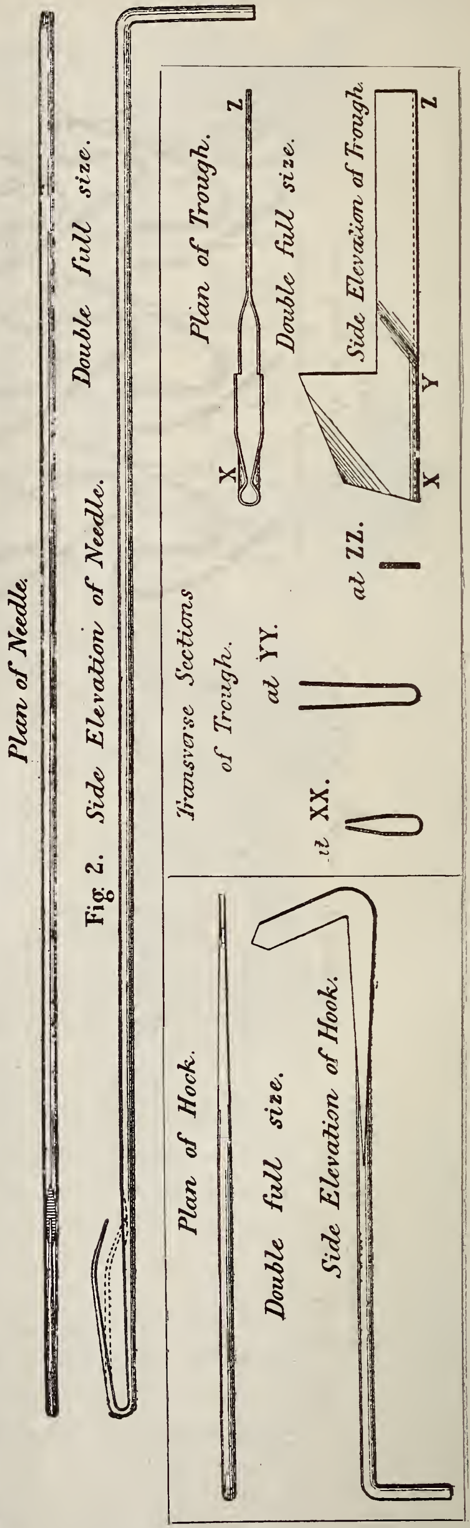
I hope I have now made intelligible the way in which the three primary parts, the trough, A, the needle, B, and the hook, C, manipulate the threads so as to produce a warp woven or knitted fabric.

I am afraid it would be wearisome beyond the endurance of an audience, composed of any but experienced mechanics, to follow all the details of the various mechanical arrangements by which the movements of these primary parts are produced in the machine, and I need only say to those who wish to study the purely mechanical part of this machine further, that they can do so by reading a paper which I read before the Institution of Mechanical Engineers of England, at their recent meeting in Paris, and which has been published in the July Proceedings of that Institution.

I have now carried the explanation of the machine so far that you will clearly understand how this machine produces cloths and fabrics—not shaped, such as the samples you have in your hands—also ordinary "ladies' clouds," also narrow tapes, such as the samples you have. The next branch of our subject will be to explain why this system of warp weaving enables the weaving to be done at so much higher speeds than can be attained, either by the ordinary system of weaving with a warp and a weft, or the ordinary system of knitting with a weft only.

Probably most of you are aware that, in the ordinary system of weaving with a warp and a weft, a shuttle or light case containing a "pirn," "cone," or "spool," with a portion of weft wound upon it, has to be thrown (or hit) across the width of the warp, each alternate thread of which is lifted up, to allow the shuttle to pass under it, while the other alternate threads are lowered, to allow the shuttle to pass over them.

Now, from this it will be evident to you that the speed of the loom is very materially influenced by the width of the fabric to be made; and of late years, in weaving cloths and other fabrics used for cutting-out coats and other articles of dress, it has been found much more economical, and to cause much less waste,

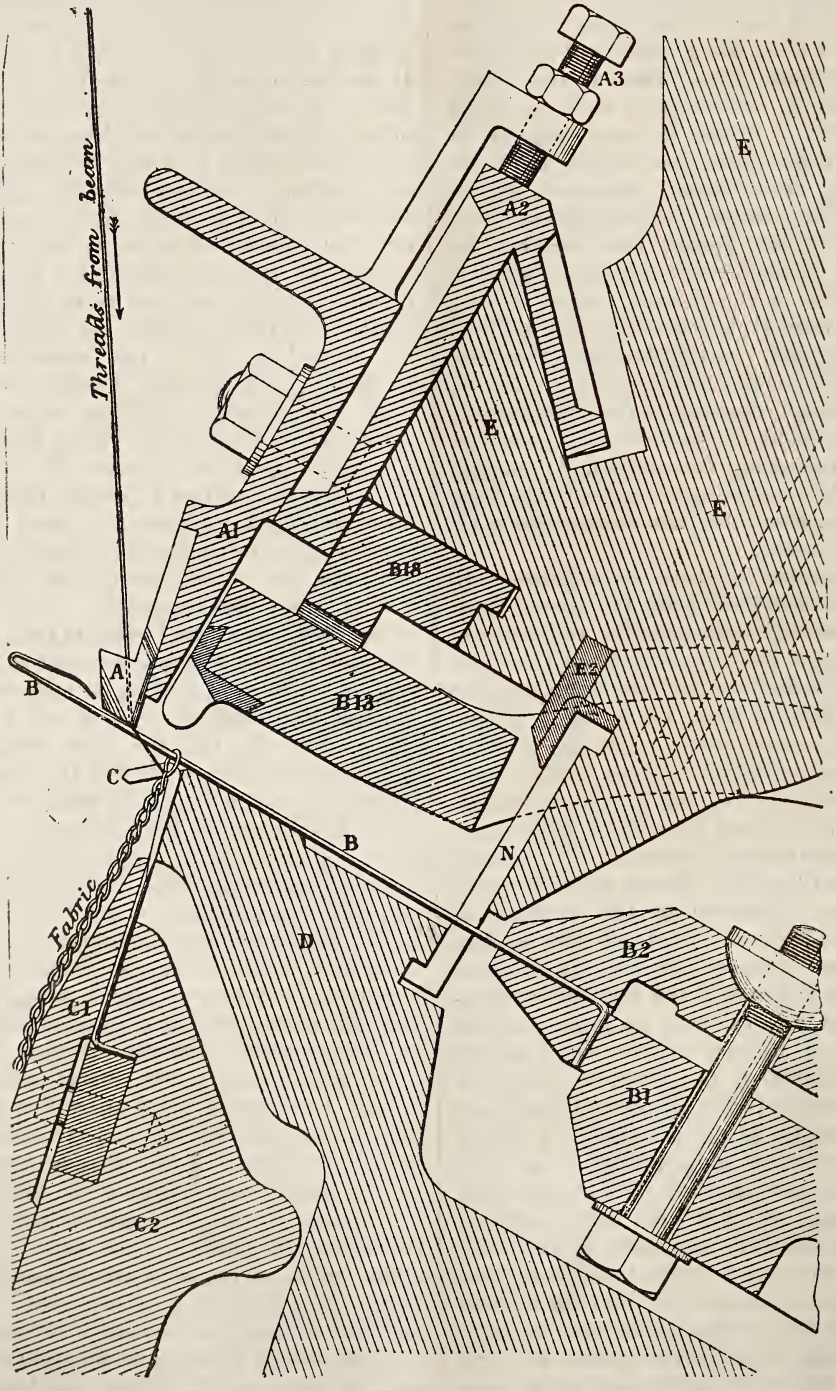


E.—Three Primary Parts of the Machine.

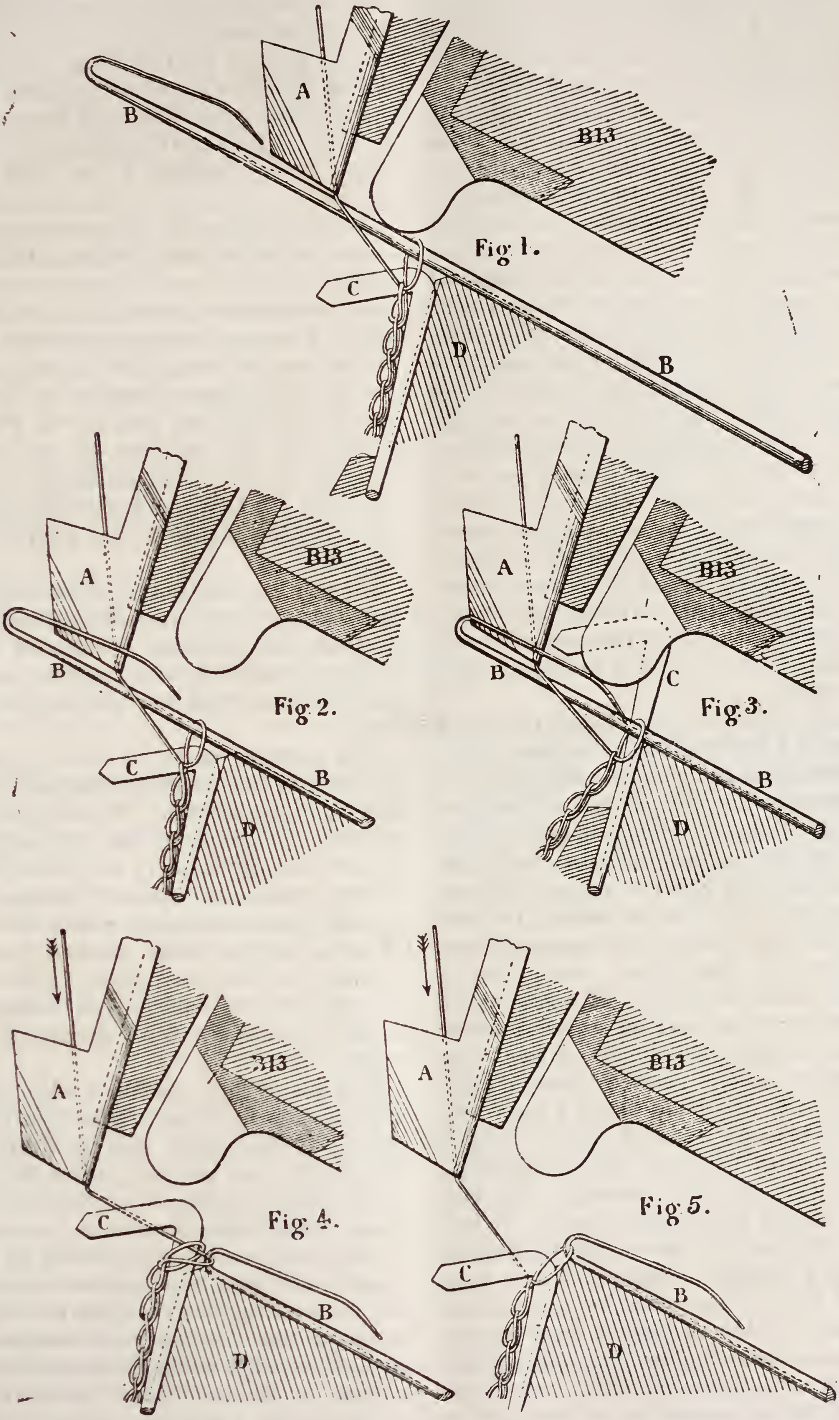
to make the loom to weave what are called "double-widths" of cloth, that is a cloth about 58 inches wide, instead of, as formerly, a cloth of about 29 inches wide; and it will be readily seen that, in cutting-out a garment such as a coat, the garment will be cut-out with less waste from a cloth of this double width than it would be in a cloth 29 inches wide. But, of course, this advantage in the cutting up of the cloth has entailed a counterbalancing disadvantage, inasmuch as the loom can only weave at a much slower speed, because of the greater time required for throwing the shuttle across the wider width of warp. Now in the system of warp weaving which I have explained to you, you will see that, within very considerable limits, the width of the fabric made, however wide it may be, does not reduce the speed of the weaving at all, unless the width required is so enormous that the bar containing the needles, B 1 (p. 250), and the bar containing the hooks, C 2 (p. 250), become so heavy that this necessitates a reduction of speed.

The machines we have made hitherto are 84 in. wide, and these make 120 rows of loops each minute quite satisfactorily; and, as far as we can judge, the widest machine for weaving cloth and similar fabrics likely to be required will be a machine about 120 in. wide; and we have every reason to believe that this machine will run just as fast as the 84 in. machine, and this gives a speed of production of the fabrics which I believe has never been attained by any previous system of weaving. It is therefore evident from this, that an unusually great advantage is attained by this machine in weaving wide cloths; but I will now explain to you why it happens also that an immense advantage is gained in this machine in weaving narrow fabrics—such as tapes and the like. In an ordinary loom weaving several widths of fabric in one loom, to produce a proper selvedge (which of course is necessary in tapes and the like) there must be a shuttle to each width of fabric produced, and this necessitates between each width of fabric (and for example we will take one, half-inch wide) a sacrifice in the width of the loom sufficient to allow a shuttle to lie in between each width of fabric woven; and the shuttles in ordinary use are from about 4 in. to 14 in. or more long. Now, in this system of warp-weaving, we can produce a satisfactory selvedge by leaving out one thread from one needle, and as the fabrics, of which you have samples, are most of them made upon a machine with twelve needles to the inch, this means that to divide the fabric woven into two widths, each width having a perfect selvedge, requires the sacrifice of only one needle; that is, only one-twelfth of an inch, instead of, as in ordinary weaving, more than 4 in. to 14 in. It therefore naturally results from this, that there is an immense advantage in this system of weaving over the ordinary loom for weaving very narrow widths as well as in weaving very wide widths. The reason why this system of warp-weaving is so much more expeditious than the system of knitting is very evident, because in ordinary knitting (as previously referred to) each loop has to be completely drawn and formed from the weft before the next loop to it can commence to be formed, and after the formation of the whole row of loops, they have to be drawn through the row of loops previously formed by a separate operation; whereas, in a warp-weaving loom, such as has made the fabrics before you, the 1,000 loops are formed simultaneously, and in the process of forming them the loops are drawn through the previous row of loops simultaneously. It perhaps will be considered that I ought to refer to the system of plaiting as another system of weaving, but, practically, plaiting is really almost identical with ordinary weaving with a warp and a weft, only that the warp, instead of being taken in a direct line with the length of the fabric, is taken diagonally with the length of the fabric, and the weft, instead of being taken in a direct line across the fabric is taken diagonally across the fabric, and plaited fabrics are, with this exception, woven in a manner similar to the ordinary weaving with a warp and a weft; but there are other reasons, which would take too long to explain here, which make the plaiting system of weaving probably the slowest system of making fabrics.

The next branch of our subject will be to explain how fabrics made upon this warp-knitting machine can be shaped during the process of weaving. I have already explained why, in warp-woven fabrics, if the lengths of the loops are increased, a material increase in the width of the fabric is made, and of course if the lengths of the loops are decreased, the width of the fabric is also decreased. It is, therefore, evident that if we add to the machine a simple method by which the machine can be made, to automatically increase the length of the loops, when desired, by certain delicately graduated steps, and then decrease the length of the loops, when desired, in a similar manner,



F.—Section of Part of Machine, full size.



G.—Cycle of Movements of Primary Parts, scale twice full size.

then fabrics, shaped as they are woven (into such shapes as may be desired), can be woven upon the machine.

I am afraid I should weary you too much with delicate and elaborate mechanical details if I went fully into the mechanical arrangements by which this is done, but I think I can make it quite intelligible to you by explaining that, by the use of small inclines attached to a chain like a flexible ladder, seen in the end view on C. (p. 246), which is made to go forward one link for every row of loops knitted, the length of the pull of the needles and the length of the pull of the hooks are easily increased or decreased at any row of loops, automatically, during a part of the 120th part of a minute required for the forming of the row of 1,000 loops, and, in fact, the increase or decrease of the length of each row of loops is easily varied exactly the two-hundredth part of an inch during less than 1·900th part of a minute; and by this arrangement the bodies of ladies' vests are so woven as to be shaped during the weaving to fit exactly to the figure, as will be readily seen by the vest shown, which has been placed upon one of the "busts" or "dummies" used by dressmakers to fit their dress-bodices to, and to display their bodices upon.

Most of you will know that, in an ordinary loom, when a weaver's beam has had all the yarn unwound from it, and woven into fabric, it is necessary to cut every thread of the warp and remove the empty beam, and put in a fresh beam; and suppose the loom has 1,000 threads in it, to tie 1,000 knots to connect the new beam of warp with the old warp. In some looms this is done in a slightly more rapid way, by having two sets of the whole internal machinery of the loom; but this system would take too long to explain; but the result of the most perfect process is, I believe that, after the emptying of one weaver's beam, it takes about three to five hours before a loom with 1,000 ends can be restarted, and in an old-fashioned warp loom the time occupied to thread the thread-guides formerly in use with a new warp is considerably longer. It was therefore evident that, having attained a speed of weaving so much higher than had been attained before, there would be a very large per-centage of loss of time in removing the empty beam, and tying the 1,000 ends of the new warp on the new beam, unless some better system could be invented.

I am afraid it would take too long to explain all the mechanical details by which this re-threading of the 1,000 threads in the thread-troughs is now done, but I can very shortly give you the general result, which is that when a beam is emptied, a new beam can be put into the machine, and it can be re-started by two girls in from 20 to 25 minutes, and during this time the whole thousand threads are accurately threaded, each thread into its right one of the 1,000 troughs, one of which is shown upon diagrams E. (p. 248) and F. (p. 250.)

Another feature of this warp-weaver and knitter is that so many curious and different patterns, similar to and different from some of those you have can be made in so exceedingly simple a manner by only varying the traverse of the troughs across the needles, *i.e.*, by giving them various numbers of traverses, first to the right and then to the left, which varying of the traverses of the thread-troughs is done automatically — without lessening the speed of the weaving—by the use of a chain similar to that used to shape the fabrics.

I hope I have now made the working of the machine as clear as is possible without wearying you with elaborate mechanical details, and it only remains for me to give you a few curious facts which may interest and amuse you.

One machine which we have at work at present is 84 inches wide, and in that 84 inches there are 1,344 needles. This machine makes 120 rows of loops per minute, that is, it makes 161,280 loops per minute; also when knitting certain classes of "ladies' clouds," this machine knits into fabric rather more than 1⅝ miles of the finest worsted yarn per minute, this being 100 miles per hour; and one girl on one machine can weave in a week of fifty-five hours 308 dozens of ladies' clouds.

Also one of these machines, when making the fully shaped bodies for ladies' vests (which bodies are woven apart from the sleeves) can be worked by one girl, and makes five bodies at one time, and this set of five bodies are woven, shaped, and complete in 15 minutes.

I feel that it now only remains for me to thank you for your great patience in listening to a paper which, I fear, has been too long, and to say that there are here many samples of the productions of this machine, and some samples of some of the mechanical details of this machine, which I shall be exceedingly glad to show to anyone who likes to see them at the close of this meeting.

DISCUSSION.

Mr. **Henry Chapman** thought it hard to add anything to what had been said. As one who had had the advantage of seeing the machine at work at the Paris Exhibition, he could endorse all that had been said about the speed and facility with which it did its work. The paper was not quite complete in one sense, viz., that with the modesty characteristic of all inventors, Mr. Paget had forgotten to mention that the invention obtained the highest award in its class at the Paris Exhibition, and that he was one of the very few English exhibitors who were honoured with the Cross of the Legion of Honour. With regard to "beaming," Mr. Paget had mentioned an expense which seemed to be necessary with the machine, which was that you should "beam" the yarn, but if he was correctly informed, Mr. Paget had succeeded lately in avoiding this necessity—instead of having to put all the threads on the beam, the machine would work by taking each thread direct from the "cop." Again, in a chain of ordinary looped stitches, when the string was pulled the loops of the chain came undone, so that he should be glad to be informed whether if a thread broke, what was called a "Jacob's ladder," was formed. If so, this must be a disadvantage of this system of weaving over all others except the stocking web, and was one of the disadvantages which had made the stockinette fabric a drug in the market. As to complication, no doubt the diagrams did look complicated, but after the paper he thought even a child would understand the machine. Each needle did its own work with its neighbour to make the fabric, and therefore there was no complication merely because there were 1,200 needles also; each presser and hook was the same as its neighbour, thus it was only a multiplication oi very simple motions.

Mr. **E. H. Carbutt** said it was a great pity that every draper in London was not present to hear this paper. He had spent more than half his life in the weaving districts of Leeds and Bradford, and when he went to see this machine of Mr. Paget's, and by the aid of his explanation was able to understand it very easily and quickly, he at once came to the conclusion that it had a great future before it. Many tailors objected to cloth woven by this machine because they said that for trousers it bagged at the knees, but he had worn for three months a suit made of it, and was never more comfortable in his life; it was the lightest suit he had ever had, and the warmest, and the great comfort was that it would give a little when required. Though it might bag a little at the knees yet if it were hung up for a short time it recovered its shape. He thought Mr. Paget had not made enough of the advantages his machine had over the ordinary shuttle loom. If this were only 3 ft. 6 in. or 4 ft. wide, it was comparatively easy to drive the shuttle across between the weft, but with a loom 7 ft. or 8 ft. wide, the shuttle had to be much heavier to stand the blow and carry the yarn, and therefore required much more power to drive it. The result was that the whole machine vibrated so much that it could only be used on the ground floor. Mr. Paget could put his looms in a mill of six or seven storeys, but an ordinary cloth weaver could not do anything of the kind; they would shake the mill to pieces, and the loom itself would also soon go to pieces; in fact the life of a loom was very short compared with what would be the life of this machine. He would ask Mr. Paget if he had had any experience of the circular knitting machines which were recently introduced for making cloth for ladies' wear, which, for a time, were very successful, but which were now going out; and perhaps he could say in what respects the material he produced was superior to that made in such machines. He hoped this machine would be shown and explained in some of the large weaving centres, say at the next meeting of the British Association at Leeds, where Mr. Paget would get a large audience who would be able to criticise, and perhaps be able to teach him something, as well as learning a good deal from him.

The **Chairman** said he might point out that Mr. Paget's modesty had prevented his pointing out the enormous number of details, in addition to the general arrangement of the machine, which had to be worked out, and which formed a truly herculean task. In the little box before him were the little walls of the presser, the trough, the hooks, and the needles, and he was certain that an enormous amount of time, thought, experiment, and expense must have been devoted to giving to each its proper form, and having done that, to find out how to produce them at a reasonable cost in the enormous number required. It seemed as if they would come to the time when a person would go into a shop, give his number, and sit down and wait while Mr. Paget's machine turned out a coat or pair of trousers. He would ask whether the vests shown were made in the flat, and sewn together, or knitted in circular form. He was not musical, and could not quite realise what the pleasures of music were, but he should imagine they were somewhat similar to what he had experienced in studying this paper. He read it up in the Proceedings of the Mechanical Engineers first, and had since studied the diagrams, and he derived the most intense satisfaction in seeing how an apparently hopelessly complicated business could be made to work harmoniously with extraordinary certainty, and produce such a great variety of fabrics. He would also ask if there was much delay in the event of breakage, and whether the knots, when tied, presented any difficulty in passing through the machine.

Mr. **Paget**, in reply, said a short time ago he should have had to say that beaming was necessary, but now, speaking positively from considerable experience, he could say "No." The machine had woven quantities of cloth direct from the "cop," the small conical cylinder—if he might use such a term—in which shape it came from the spinning machine; 1,008 of these cops were arranged on a "creel," and woven from them direct. The ordinary way of putting the yarn from the cop on to the beam, and preparing it for weaving, cost nearly as much as the weaving itself, and that was now entirely dispensed with, and he could show anyone who would go into the figures that he could now weave cloth at less than one-sixth the cost formerly incurred between the spinning the yarn, and delivering it woven to the dyer and finisher. As to the question whether this material unroved, as it was called, or ran down with a "Jacob's ladder," he would only say that there are 1,008 ends in a piece of that cloth, and his machine wove those ends together. An American, at the Paris Exhibition, asked him if this could be unroved, and he told him that if he could invent a machine which would unweave it and pull those ends out he would "take a back seat." If one thread in a stocking were broken it ran of itself, and you had a ladder directly, but here you must pull the whole thousand ends with exactly the same force, otherwise the threads are "locked" immediately. He was not going to try to invent a machine which would do that. He was glad to say that since Mr. Carbutt had the suit he had spoken of the machine had been altered, and cloths were now woven much more closely. Stockinettes had now a very evil reputation, and he must say "stank in the nostrils" of all who had anything to do with them, either in making, selling, or wearing, and the main reason was that, unfortunately that method of weaving gave the power of knitting the face of the cloth with good yarn, whilst the back might be pure unadulterated "shoddy," and that was too great a temptation for human nature to resist, consequently, the material got a bad name. Another thing was, that owing to the construction of the stockinette machine it was absolutely impossible to knit as solid or closely woven cloths, as in this one. It was his thirty years' knowledge of knitting machines which enabled him so to construct this one so that he could knit more closely than had ever been done before. Very little strength or thickness was required in the needles, as the only strain upon them was lengthways, and therefore they also might be very thin, whereas in the stockinette machine they had to be tolerably thick, or the work would be irregular. He had three of these machines at work, none on the ground-floor, and they did not shake the floor at all; his knowledge of knitting-machines enabled him to proportion the parts properly. A few days ago, he took a foreigner who came to see him to one of his tenants who had on the third floor a knitting-machine which had been running constantly for thirty years, and it looked good for another ten years' wear. He was quite sure that no loom in Bradford would stand so much work as that. But these machines ought to last as long because there was no more wear upon them. He did not know exactly the power required to drive a loom, but he felt certain it would be more than double that required for this machine. With regard to the vests, as the sleeve had to be joined to an arm-hole in the body, it was found more economical to make them with a seam up the side, because there were then two selvedges to join, instead of cutting into the fabric to insert the sleeve. The vest was shaped, however, in the knitting, front and back as required.

Mr. CARBUTT said there was one point worth attention from a manufacturer's point of view, viz., that when working with a warp and weft, you had to keep a much larger stock of material.

Mr. PAGET said that was so, and the warp and the weft required entirely different classes of spinning machines; using warp only, you needed only one kind of yarn. In weaving four beams there would be on an average one thread out of every 1,000 broken in an hour, which would necessitate the stopping of the machine for about one minute. The knots were easily tied. He had run 1,008 needles for six hours with only three broken, and these stopped the machine for about one and a half minutes each. The needles cost 17s. 6d. per thousand, so that the cost occasioned by broken needles was very slight.

Mr. CHAPMAN said all the samples which he had seen were made with the same machine and the same needles. The only time lost was in changing from wool to cotton, or from one colour to another, and the longest time taken in making the change was twenty minutes.

Mr. PAGET said the football jerseys exhibited were shaped automatically, and he had recently added an apparatus by which the pattern was also varied automatically, and at a certain point a zigzag was introduced instead of a stripe. Within twenty-five minutes, the machine could be changed from making a material-like horse-cloths to make a fine thin flannel, and with another change in twenty minutes, it would produce ladies' clouds.

Mr. ALFRED CARPMAEL asked if Mr. Paget would describe the chain by which the length of the loops was varied.

Mr. PAGET exhibited a portion of the chain, which was known on the Continent and in America as the "Paget" chain, but he was not the inventor. In the year 1851, he wanted a chain which would allow of any number of links being taken out or inserted easily, and being in the Palais Royal, in Paris, he noticed a peculiar chain with which a man was winding up his awning. He was told it was a *Chaine Vaucanson*, and was in common use for that purpose, and it had been invented by the celebrated engineer of that name. For a long time he supposed him to be the original inventor, but one day in the Antiquarian Museum, in Edinburgh, he saw a case unpacked which contained relics from the tomb of one of the abbots in an old Scotch monastery, and round the waist of the abbot was found a piece of the same kind of chain, only the spiked ends of the wire-links pointed inwards; and the ancient saint had worn this girdle until the spikes had eaten into him and killed him, and thus be obtained canonisation.

The CHAIRMAN then proposed a vote of thanks to Mr. Paget, an old college mate of his, who had always shown remarkable inventive ability, and who had, from time to time, brought out many useful inventions, but none he thought equal to that which he had so ably described and so splendidly illustrated that evening.

The vote of thanks was carried unanimously, and the proceedings terminated.

[A few of the packets of samples distributed at the meeting are still in hand, and, as far as they will last, a copy will be sent to any member of the Society on application to the Secretary.]

Miscellaneous.

COLOUR-BLINDNESS.

Mr. Brudenell Carter's paper, read before the Society on Wednesday, 22nd ult., has attracted considerable attention, and led to a long correspondence in the *Times*, from which the following letters are extracted:—

Prof. SILVANUS P. THOMPSON wrote on January 20th:—

"Circumstances prevented me from hearing Mr. Brudenell Carter's very interesting paper on colour-blindness at the Society of Arts, or from taking part in the discussion. To me it seems that Holmgren's test, though far the best hitherto devised, is defective in an important respect. According to the method of that test, the person examined is directed to pick out from a heap of coloured wools or silks those that resemble a given specimen of a particular colour. No doubt such a test would be satisfactory enough if the persons to be tested were about to be employed in watching for signals made in full daylight by the exhibition of surfaces which reflect various tints with different degrees of luminosity and of intensity of colour. But the facts are quite other. The sailors, pilots, and railway men for whom such tests are designed are required to discriminate between signals made in dark or dusk by the exhibition of coloured lamps.

I submit, then, that a far truer test of colour vision, for such a purpose, would be afforded by bringing the person to be tested into a dark room wherein one small candle was burning at a distance of, say, 15 ft., the person under test being required to select from a heap of samples of coloured glasses, of the same actual tints as those used for railway signals and lights at sea, those which are respectively of the different colours."

Mr. BRUDENELL CARTER answered on the following day:—

"May I be permitted to say, in relation to the letters on colour-blindness in this morning's paper, that Professor Silvanus Thompson, when he describes Holmgren's test as one in which the examinee is required to pick out from a heap of coloured "wools or silks," shows that he has not taken the trouble to make himself acquainted with the subject on which he writes. Professor Holmgren expressly excludes silk as an unsuitable material for the purpose. I think I could prove to Professor Thompson in five minutes that his conception of the value of the test is as mistaken as his description of the mode of conducting it."

Professor THOMPSON replied on 25th January:—

"It matters little to my argument whether the colour-test be carried out with skeins of coloured wools, or with coloured silks as used in America, or with 'a few pieces of red, green, blue, and yellow paper' (p. 66 of Mr. Brudenell Carter's 'Practical Treatise on the Diseases of the Eye'). All these methods, by whatever name known, are equally open to the objection that they are daylight tests. No one knows better than Mr. Brudenell Carter how enormously the sensibility of the eye is increased in darkened surroundings and diminished in a full blaze of light. My point is that as sailors and railway men have to distinguish points of light in darkness, the method of testing their colour vision upon coloured lights in a darkened room must necessarily be fairer to them, and truer in result, than the method of testing them in broad daylight by wools or silks, or by a few bits of coloured paper."

Mr. BRUDENELL CARTER'S answer to Prof. Thompson was dated 27th January:—

"Professor Silvanus Thompson returns to the charge this morning, and says that the error in his former letter does not affect his argument. I did not preserve the letter, and did not notice any argument, but only two erroneous statements, one of which I corrected. The second erroneous statement —to the effect that coloured lights furnish trustworthy tests of colour-blindness—has the single merit of seeming plausible until it is critically examined; but it has been so frequently refuted, both by reasoning and by experience, that it is only necessary for Professor Thompson to make himself acquainted with the literature of the subject in order that he may feel much regret at having lent the sanction of his name to a very dangerous delusion. It would be impossible for me to trespass upon your space with any attempt at a demonstration. I may, however, point out that the passage cited by Professor Thompson from a book of mine published 15 years ago does not refer at all to the detection of natural colour-blindness, but specifically to the requirements "of the surgeon" in detecting that which has been produced by disease. My views on testing for industrial purposes were stated in a course of Cantor lectures delivered before the Society of Arts in 1881, and have remained substantially unchanged.

I received this morning an interesting letter from Dr. Joy Jeffries, of Boston, U.S.A., who next to Holmgren, is the greatest living authority on the subject, and who confirms every word that I said last week at the Society of Arts. He declares the use of coloured lights for testing to be "simply ridiculous, perfect as the method may seem to the laity." "We" (in America), he writes, "got through this aspect of the question ten years ago." Again, "You English gentlemen will have a good deal before you as to the sea after the Maritime Conference Report has been published. I expect your Mr. Gray will pigeon-hole all the colour-blind and vision part, as well as the Parliamentary report when made." It would seem that the Board of Trade does not command the confidence of Transatlantic experts."

Professor THOMPSON wrote again on the 28th January:—

"Mr. Brudenell Carter still ignores my contention that for the purpose of testing the eyesight of sailors and railway men, whose duty is to distinguish points of light amidst surrounding darkness, a test involving the discrimination of coloured lights in a darkened room must necessarily be a truer test than one based upon the inspection of tinted surfaces in broad daylight, when, by reason of the surrounding glare, the eye is less sensitive than it is in darkness. He has not furnished a single line of proof that the eye is more sensitive in broad daylight, or that a dull greenish grey (such as one of Holmgren's test wools) is any better test of eyesight when viewed in a blaze of light than the corresponding tint would be if produced by coloured glasses amidst surrounding darkness. I observe that he states that the passage which I quoted from his book 'does not refer at all to the detection of natural colour-blindness, but specifically to the requirements of the surgeon in detecting that which has been produced by disease.' I may be very obtuse, but the paragraph on page 66 begins with the words:—'It is sometimes necessary to test the power of recognising colours, a power which may be *either congenitally defective* or impaired by disease. In determining the *fitness of men to be railway servants, or to keep watch on board ship*, or to discharge any other duty for which the prompt recognition of the difference between red and green is necessary, the state of the eye with reference to colour perception should always be carefully investigated. . . . . . The requirements of the surgeon will be fully supplied by a few pieces of red, green, blue, and yellow paper, or by sets of types printed in these several colours.' Am I now to understand that the words I have italicised refer not to natural colour-blindness, and only to the 'requirements of the surgeon?'

"It is truly strange that, whilst the methods of Holmgren and others for testing colour perception by inspection of coloured stuffs by broad daylight are lauded almost into a species of cult, the much more truly scientific mode of testing colour vision which has been worked out by Captain Abney and Major-General Festing has remained almost entirely neglected. Holmgren's method gives at the best a merely qualitative discrimination of the perception of green and red sensations. Abney's method gives a quantitative of the perception, not of green and red alone, but of all the successive colours of the entire spectrum, from red to violet. Of course, one who agrees with Mr. Brudenell Carter 'in regarding any imperfection of the colour-sense, however small, as an absolute disqualification for such employment' would rather not know of a scientific method of testing which proves that men's perception of colour is just as individual a matter as the shape of their noses; and that no two individuals see the whole of the colours with the same relative intensity. But that is a fact which Holmgren's most imperfect method would be quite incapable of showing.

"As to Mr. Brudenell Carter's delicate intimation that I am imperfectly acquainted with the literature of this topic, I can afford to pass it by. It is well to be acquainted with its literature; it is better to be acquainted with its science.

"In conclusion, I may point out that in Mr. Brudenell Carter's letter in your issue of the 27th, he has fallen into a blunder. Pray excuse the bluntness of the term. I cannot call it an 'error,' as I perceive that that term is used by Mr. Brudenell Carter to connote any difference of scientific opinion from his own. He is trying to explain the failure of certain persons to distinguish at a distance the colours of flowers which they can readily distinguish when nearer; and he ascribes this failure to the law of inverse squares. It is, however, not true that the intensity of the colour varies inversely as the square of the distance. Let me be precise. Supposing a piece of scarlet woollen cloth 1 foot square is held in front of the eye at a distance of 50 feet in broad daylight; the image on the retina of the normal eye will be a small square patch of brilliant scarlet about 1-50th of an inch each way. If the same object be viewed from a distance of 100 feet, the small square patch on the retina of the eye will be now about 1-100th of an inch each way, The intensity of its colour will be exactly the same as before, but its size will be one-quarter of what it was."

The following letter from Mr. BRUDENELL CARTER was written on the 2nd inst., and appeared in yesterday's *Times*.—

"When I ventured to point out in your columns to Professor Silvanus Thompson, a short time ago, the error of his belief that coloured lights would afford trustworthy tests of the accuracy of colour-vision, and the ease with which he might convince himself of this by reference to the literature of the subject, I had no idea of giving offence. The literature in question (that, namely, of colour-vision testing for industrial purposes) is not very accessible, and might easily escape the notice of any one whose attention had not been specially directed to it. It records the employment of coloured lights in the first crude attempts to test colour-vision in almost every country, and their general abandonment when Professor Holmgren had proved their uselessness for the purpose. Professor Thompson, in his reply, suggests rather than declares that he is familiar with the literature in question; and if this be so, and if Holmgren's conclusive refutation of his error has made no impression upon him, I confess that I should be inclined to dismiss his case as an incurable one. There may be others, however, who do not share Professor Thompson's familiarity with Holmgren's work; and with your permission, I should be glad to try and make clear to them why it is that coloured lights are not to be relied upon for testing. The object of the test, it must be remembered, is not to ascertain whether A B distinguishes a red light from a green one on a certain occasion and in certain circumstances, but whether he may be trusted to do so on every occasion and in all circumstances; whether, in short, he has such a colour sense that red and green are absolutely different to his perceptions, and incapable of ever being confounded, or such a one that they present to him only differences of brightness and not differences of colour, the former, moreover, being only recognisable at short distances.

"The state of colour-blindness (putting aside the rare cases in which no colour is visible) may be defined as an inability to see one of the three primaries of the spectrum, the red, the green, or the violet, and this inability may be complete or incomplete. Blindness to violet is very rare, and is of no industrial importance except, perhaps, to dyers; but blindness to either red or green affects, in round numbers, 4 per cent. of males in every civilized country. Inasmuch as all colours, except the three pure primaries of the spectrum, are mixtures of these primaries, it follows that an inability (complete or incomplete) to see one of the primaries must modify the appearance of every mixture of which it forms part, and, hence, that the general colouring of nature differs, in the eyes of the colour-blind, from the appearance which it presents to the eyes of the colour-sighted. The colour-blind fail to recognise differences which are manifest to the colour-sighted, and they see resemblance where the colour-sighted see none. The only trustworthy test of their condition is furnished by causing them to point out the things which appear to them to be of the same colour, and also the things which appear to them to be of different colours.

"To an absolutely red-blind person a red lamp would not be invisible, but would appear as a light of a trifling luminosity, as a dull light; and to an absolutely green-blind person a green lamp would present the same appnarance. In proportion as the colour-blindness was incomplete the brightness of either lamp would be increased. The difference of luminosity would be altered in its degree by the precise tint, and by the thickness of the red or green glass, by the brightness or dimness of the actual flame behind the glass, and by rain, hail, smoke, fog, and various other atmospheric conditions. In order to test colour-vision with actual signals upon a line of railway, it would be necessary to exhibit the lights at various distances, with lamps of different degrees of brightness, and in all weathers, so that weeks or months might be required for the entire process, and there would, on every occasion, be an even chance of the examinee, if colour-blind, being right in his guess. If he were tested in actual working, there would be much more than an even chance, because he might ascertain beforehand what signals were likely to be displayed. On any given occasion, to be right in his first guess would be to be right all through, because the two lights would exhibit their (to him) characteristic differences of luminosity, when seen alternately or in irregular succession. The proposal to use coloured lights, seen through small apertures in an otherwise dark room, still leaves the clue which is afforded by the unequal luminosity, as well as the even chance of a right guess; and moreover, the method is not trustworthy on account of the shortness of the distance. Buring the last few days, I have examined at my house two gentlemen of far more than average intelligence, one of them a Fellow of the Royal Society. They had both discovered and repeatedly proved their inability always to distinguish railway signal lamps, and both admitted their utter unfitness to be engine drivers. They both committed characteristic errors when tested by Holmgren's method, and they never make a mistake when a red or a green glass was held over a small aperture with a gas light behind it, at distances ranging from 12ft. to 20ft. They would have passed such a so-called test triumphantly.

"I think it will help to render matters clear if we suppose the existence of a class of persons with perfect vision in all other respects, but who, from some structural peculiarity, are unable to see the figure 9, and if we further suppose that examinations are held for the express purpose of discovering such people, and of preventing them from becoming teachers of arithmetic. A possible method would be to hold up before them at proper visual distance a row of figures, say, 92684, or 35689, or 64325, and to say, 'Does that row contain a figure 9 or not?' There would obviously be an even chance of a correct answer on any single occasion, and, if the figure 9, although not actually visible, yet impressed some slight difference of appearance on a row in which it was present, as contrasted under the same conditions of illumination with one from which it was absent, the even chance after one correct guess would become almost or quite a certainty. This is the practical effect of testing colour-vision with the lamps which are used in signalling, or with any smaller imitations of them.

"Suppose, however, instead of the method just described, the examiner were to write down a series of addition sums, such as those below, and were to say, "Here are seven addition sums, placed side by side, and lettered respectively A, B, C, D, E, F, and G. Add them all up, and select those which amount to the same total as A.'

A	B	C	D	E	F	G
4	7	8	6	9	9	9
6	3	2	3	1	9	8
8	8	7	7	3	2	7
3	4	5	4	4	3	3
2	1	3	2	3	2	4
5	5	3	3	8	3	6
28	28	28	25	28	28	37

"It is obvious that a person who could see the figure 9 would select sums B, C, E, and F, as those which yielded the same total as A, and would reject D and G; while a person who could not see 9 would select B, C, and G, and would reject E and F, as well as D. This is strictly what happens in the application of Holmgren's test. To the colour-blind an element in the production of colour, comparable to the figure 9 as an element in the production of number, is invisible, so that he leaves it out of his calculations, and stands confessed by doing so. The test is conducted in the following manner:—

"A table covered with a white cloth is placed in good daylight, but away from direct sunshine, and on this table is put a heap of skeins of Berlin wool, perhaps twenty or thirty in number. The heap contains several greens, and several shades of drab, fawn-colour, yellow, stone-colour, and pink, all very pale —that is, much diluted with white. The examiner selects as a pattern a skein of very pale grass-green, and places it on the left of the heap. He then instructs the examinee to stand before the table with his hands behind him, to look at the pattern and at the heap, and to pick out of the heap and to place with the pattern every skein which appears to him to be of the same colour, without reference to lighter or darker shades. He must make his selection with the eyes alone, and must only put out a hand to pick up what he has chosen. No colour names are to be mentioned. A person with normal colour-sight will pick out the eight or ten greens in as many seconds, and will leave all the rest. A person who is blind to green does not see the green element of colour in the pattern skein, and a person who is blind to red does not see the element of red in the fawns, pinks, drabs, and yellows, which are technically called "confusion colours." Even if his defect be very slight he betrays it by selecting slowly and carefully. If it be more than very slight (although far short of complete blindness to red or to green) he will infallibly select some of the confusion colours, and will usually leave some of the greens behind. The test, so far, establishes whether the examinee possesses normal or defective colour-sense, and establishes it beyond the possibility of question. Further developments, which need not here be described, show whether colour-blindness is complete or incomplete, and whether it is to red or to green.

"It is not too much to say that no one who fails in the first part of Holmgren's test is fit to drive an engine or to control the course of a ship. The two gentlemen whom I have already mentioned, both of whom knew and admitted their inability to distinguish signal lamps, were at once detected by Holmgren's method, and would only have been detected by colour lighted in certain conditions which might not have been present when the so-called test was applied. The proper time for applying Holmgren's test is manifestly during childhood, before the colour-blind are committed to occupations for which they are unsuited; and it is obvious that railway directors and shipowners should have men tested before engaging them.

"The only possible usefulness of coloured lights, in relation to the matter, is that which I fully described before the Society of Arts, as one among several methods of estimating the precise degree of defective colour-sense, when the fact of incompleteness has been proved by Holmgren's method.

"Professor Thompson accuses me of having blundered in my explanation of the reason why the visibility of colour to the partially colour-blind rapidly diminishes with increasing distance. It appears to me that he has left out of consideration an element of the question which is so obvious that I did not occupy space in mentioning it, and that the blunder is with him rather than with me. The point is not worth further discussion.

"Your correspondent, "Justice," calls upon me to cite cases in which railway accidents have been produced by colour-blindness, on pain of being convicted of wrongfully condemning the companies and the drivers. I do not see that his signature justifies his demand. I have condemned nobody, unless it be the railway companies who use deceptive tests. The question of the proper methods of testing colour-vision was being warmly discussed among railway men, and hence I was invited by the Council of the Society of Arts to describe how it ought to be done. I do not keep a record of railway accidents, but the information which "Justice" requires may be found scattered through various publications on the subject. Railway managers could tell him something of the frequency of disputes as to the light which was displayed on a given occasion; and in some of the accidents which, in the absence of any other probable explanation, have been attributed to colour-blindness, the driver has been killed, and his vision placed beyond the reach of inquiry. There is every reason to believe that the loss of the French passenger steamer, the *Ville de Havre*, was occasioned by the colour-blindness of the officer in charge of her; and Dr. Joy Jeffries traced out a pilot who was responsible for a very disastrous collision, in American waters, between, if I remember rightly, the *Isaac Bell* and the *Lumberman*, and proved that he was colour-blind. Mr. Clement Stretton, C.E., consulting engineer to the Associated Society of Locomotive Enginemen and Firemen, in the *Railway Herald* of the 4th of January, describes the case of a driver who was fined for overrunning a signal which he declared to be green, while all the other men said it was red, and who was only saved from subsequent mistakes by his fireman, who was accustomed to say 'Stop, mate.' I hear it is said in other quarters that I have exaggerated the dangers arising from colour-blindness among railway men, but as I have no recollection of having made any attempt to estimate them, I do not see how this charge can be maintained. I referred to such dangers as existing, and that was all. It may be worth while to arrive at some notion of the extent of these dangers, and the materials for doing so are at hand.

"Let us suppose a railway company to be possessed of 1,000 locomotives, and to have in its employment 1,000 drivers and 1,000 firemen, to none of whom any test of colour-vision has been applied. The latter supposition is not an extravagant one, because the so-called tests used by the companies, whether with lights or with coloured objects, are generally useless. In the whole number of men there would presumably be 40 colour-blind drivers and 40 colour-blind firemen. There would obviously be one chance in 25 that any given engine would have a colour-blind driver. The probabilities are that this driver would recognise his own frequent uncertainty about lights, and that he would habitually seek assistance from his fireman, and thus be preserved from accident. I do not know to what extent the conditions of the work leave a fireman at liberty to look out, or how far he would be entitled to interfere with the driver if he saw him running past a red light; but I should regard the presence of the second man upon the engine as a great source of security. With the figures given, however, there would be a probability that a colour-blind driver would be assisted by a colour-blind fireman on one engine in 625. I should not like to be a passenger by the train when this particular combination of incapacity was in control.

"One final word to Professor Thompson, who once more endeavours to refute me from my own book. This book was published in 1875, two years before Professor Holmgren wrote on "Colour-Blindness and its Relations to Railroads and the Marine," and consequently two years before his method of testing was made known. The knowledge of changes in colour-vision from disease was then in a very rudimentary state, and no surgeon, as far as I am aware, had ever been asked to test colour-vision for industrial purposes. I had, however, sufficient foresight expressly to exclude these when I wrote that the coloured objects then commonly employed were sufficient for the purposes of the surgeon—that is, for ascertaining whether the power to distinguish colours had been impaired by disease."

Obituary.

Dr. Buys-Ballot.—Professor C. H. D. Buys-Ballot, the celebrated meteorologist, died on Sunday night, 2nd inst., at the age of 73. From 1847 till 1887 he filled the office of Professor of Physical Science at the University of Utrecht, and in 1854 he founded the Royal Meteorological Institute of Utrecht, of which he was for many years director. In 1857 he announced the well-known "Law" which is named after him upon the direction of the winds. In 1873 he published his suggestions for the adoption of a uniform International system of meteorological observations. He was an industrious writer on meteorological subjects, and his papers up to 1873 recorded in the Royal Society Catalogue number 41. Dr. Buys-Ballot was elected an honorary life member of the Society of Arts in 1876.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

FEBRUARY 12.—GEORGE FINDLAY, General Manager London and North-Western Railway, "Modern Improvements in Facilities for Railway Travelling." SIR DOUGLAS GALTON, K.C.B., F.R.S., will preside.

FEBRUARY 19.—Prof. SILVANUS P. THOMPSON, D.Sc., "The Organisation of Secondary and Technical Education in London."

FEBRUARY 26.—ARTHUR MONTEFIORE, "The English in Florida."

MARCH 5.—J. TRIPPLIN, "Recent Progress in British Watch and Clock Making."

MARCH 12.—SIR DOUGLAS GALTON, K.C.B., D.C.L., F.R.S., Vice-President of the Society, "The Chemin de Fer Glissant, or Sliding Railway."

MARCH 19.—J. S. KELTIE, "Commercial Geography."

MARCH 26.—G. N. HOOPER, "Carriage Building and Street Traffic in England and France."

Foreign and Colonial Section.

Tuesday afternoons, at Five o'clock:—

February 18.—J. Henniker Heaton, M.P., "Ocean Penny Postage and Cheap Telegraph Communication between England and all Parts of the Empire and America."

March 18.—James W. Wells, M.Inst.C.E., "Brazil."

April 22.—Sir John Stokes, K.C.B, "The Danube and its Trade."

Indian Section.

Friday afternoons, at Five o'clock:—

February 7.—Dr. Schlich, "The Utility of Forests and the Study of Forestry."

February 28.—William Sherriff (of the Rangoon Chamber of Commerce), "The Northern Shan States and the Burma-China Railway."

Applied Art Section.

Tuesday evenings, at Eight o'clock:—

February 11.—W. R. Lethaby, "Cast Iron and its Treatment for Artistic Purposes." H. H. Statham, F.R.I.B.A., will preside.

Cantor Lectures.

Monday evenings, at Eight o'clock:—

Professor Silvanus P. Thompson, D.Sc., M.I.E.E., "The Electro-magnet." Four Lectures.

Lecture IV.—February 10.—*Electromagnetic Mechanism.*—Range of action of various forms of electro-magnets. Plunger and coil. Equalizers. Modes of preventing sparks.

Thomas Bolas, F.C.S., "Stereotyping." Three Lectures.
Feb. 17, 24; March 3.

Popular Lectures.

Saturday afternoons, at Three o'clock:—

Professor Vivian Lewes, "The Atmosphere." Four Lectures.
March 8, 15, 22, 29.

MEETINGS FOR THE ENSUING WEEK.

Monday, Feb. 10...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Prof. Silvanus P. Thompson, "The Electro-magnet." (Lecture IV.)

Geographical, University of London, Burlington-gardens, W., 8½ p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. Shelford Bidwell, "Electrical Phenomena in Nature."

Surveyors, 12, Great George-street, S.W., 8 p.m. Mr. G. M. Freeman, "Some Suggested Amendments in the Law and Practice of Compensation."

Tuesday, Feb. 11 ... SOCIETY OF ARTS, John-street, Adelphi, W C., 8 p.m. (Applied Art Section.) Mr. W. R. Lethaby, "Cast Iron and its Treatment for Artistic Purposes."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. G. J. Romanes, "Before and after Darwin." "The Post-Darwinian Period." (Lecture IV.)

Medical and Chirurgical, 20, Hanover-square. W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on Mr. W. H. Wheeler's paper, "Bars at the Mouths of Tidal Estuaries."

Photographic, 5a, Pall-mall East, S.W., 8 p.m. Annual Meeting.

Anthropological, 3, Hanover-square, W., 8½ p.m. 1. Dr. Garson, Exhibition of some Skulls, dredged by Mr. G. F. Lawrence, from the Thames, in the neighbourhood of Kew. 2. Mr. T. W. Shore, "Characteristic Survivals of the Celts in Hampshire."

Colonial Inst, Whitehall-rooms, Hotel Métropole, Whitehall-place, S.W., 8 p.m. Mr. Lesley C. Probyn, "The Money of the British Empire."

Horticultural, Drill-hall, James-street, Victoria-street, S.W., 3 p.m. Annual General Meeting.

Wednesday, Feb. 12...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. George Findlay, "Modern Improvements in Facilities for Railway Travelling."

Graphic, University College, W.C., 8 p.m.

Microscopical, King's College, W.C., 8 p.m. Annual Meeting. Address by the President.

Pharmaceutical, 17, Bloomsbury-square, W.C., 8 p.m

Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m.

Patent Agents, 19, Southampton-buildings, W.C, 7½ p.m. 1. Mr. C. M. Owen, "Certain Features of Joint Proprietorship in Patents." 2. Mr. Lloyd Wise and Mr. Herbert Lapage, "The Argentine Republic as a Field for Invention."

Sanitary Institute, 74A, Margaret-street, W., 8 p.m. Mr. Keith D. Young, "Dwellings for the Labouring Classes."

Thursday, Feb. 13...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 6 p.m, Mr. Aubrey J. Spencer, "The Law Affecting Passengers by Railways."

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. A Musical Lecture by Mr. J. C. Ames.

Royal Institution, Albemarle-street, W., 3 p.m. Rev. Canon Ainger, "The Three Stages of Shakespere's Art." (Lecture I.)

Camera Club, Bedford-street, Strand, W.C., 8 p.m. Mr. Graham Balfour, "Landscape."

Mathematical, 22, Albemarle-street, W., 8 p.m.

Electrical Engineers, 25, Great George-street, S.W., 8 p.m. Mr. James Swinburne, "The Theory of Armature Re-action in Dynamos and Motors."

Friday, Feb. 14...United Service Inst., Whitehall-yard, S.W., 3 p.m. Mr. H. Dent Gardner, "Chronometers."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p m. Prof. J. A. Fleming, "Problems in the Physics of an Electric Lamp."

Astronomical, Burlington-house, W., 3 p.m. Annual General Meeting.

North-East Coast Institute of Engineers and Shipbuilders, Sunderland, 7.40 p.m. Messrs. W. Kilvington and A. Taylor, "Boiler Furnaces."

Quekett Microscopical Club, University College, W.C., 8 p.m.

Clinical, 20, Hanover-square, W., 8½ p.m.

Saturday, Feb. 15...Royal Institution, Albemarle-street, W., 3 p.m. Lord Rayleigh, "Electricity and Magnetism." (Lecture I.)

Journal of the Society of Arts.

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FRIDAY, FEBRUARY 14, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

Professor Silvanus P. Thompson, D.Sc., delivered the fourth and last lecture of his course on "The Electro-Magnet," on Monday evening, the 10th inst., the special subject being electro-magnetic mechanism. On the motion of the Chairman (Mr. W. H. Preece, F.R.S.), a vote of thanks to Prof. Thompson for his valuable lectures was carried unanimously.

The lectures will be printed in the *Journal* during the summer recess.

POPULAR AFTERNOON LECTURES.

The Council have arranged for a course of popular lectures to be given by Professor Vivian Lewes, on the following Saturday afternoons at Three o'clock, March 8, 15, 22, 29. The subject will be "The Atmosphere."

The lectures will be of a popular and elementary character, and will be fully illustrated by experiments.

The regulations for admission will be the same as for the Cantor Lectures, each member having the privilege of admitting one friend.

INDIAN SECTION.

In consequence of the inconvenience caused by meetings of the Indian Section falling upon the Indian mail day, the Council have resolved to alter the day of meeting from Friday to Thursday. The next meeting therefore will be held on Thursday, 27th inst. instead of Friday, 28th, and the subsequent meetings will be held on March 13th, April 17th, and May 22, all at Five p.m.

Proceedings of the Society.

INDIAN SECTION,

Friday, February 7, 1890; Major-General J. Michael, C.S.I., in the chair.

The Chairman, in introducing Dr. Schlich, said that his paper was sure to command attention and respect from the fact that Dr. Schlich, after a forest education in Germany, spent upwards of twenty years in the Forest Department of India, where he rose to the highest rank, viz., Inspector General of Forests. On leaving India he was appointed by the Secretary of State Professor of Forestry at the Royal Engineering College at Coopers' Hill, where he is now preparing students for forest service.

The paper read was—

THE UTILITY OF FORESTS, AND THE STUDY OF FORESTRY.

By Dr. W. Schlich.

The Committee of the Society of Arts was kind enough to ask me to read a paper before this Section of the Society, either on Indian forestry or forest science. When this invitation reached me, I had undertaken to read a paper before the Royal Colonial Institute on "Forestry in the Colonies and in India." This prevented my selecting Indian forestry for the subject of my paper on this occasion, a choice which would otherwise have been most appropriate. Under these circumstances I propose to offer, to-night, a few remarks on the general utility of forests, and the study of scientific forestry. I trust that the present paper will serve as a useful companion to that which I propose to read before the Royal Colonial Institute on the 14th of next month.

At the outset it seems desirable that I should draw attention to the difference which exists between the terms "wood" and "forest." Under wood, woodland, or plantation, we understand an area of defined limits, which is stocked with trees or shrubs, and managed for the production of timber, firewood, and such other produce which, ordinarily, accompanies the rearing of trees. Forest, on the other hand, conveys to us something more. If we go back to old English history we find that it meant, principally, a tract of country which was stocked with deer; such tracts might contain trees or not. Even in the present day, some of the Scotch deer forests contain on trees at all, though in most cases woods are thrown in.

From the oldest times the forests were under special laws, called "forest laws," and we frequently read how they pressed heavily on the people, and how they were limited in their operation from time to time. Even in our own days we hear a good deal of agitation against the maintenance of the Scotch deer forests.

With the increase of population and the extension of cultivation, land became more valuable, and the extent of the forests in the old sense decreased. Considerable portions of the English forests were planted, so that a forest now conveys to our mind a tract of country which consists of a series of woods of greater or smaller extent, separated more or less by bare spots. This is, for instance, the picture which the well-known New Forest now presents. In other European countries the economic principle prevailed at a much earlier period and to a greater extent, and there forests mean now-a-days tracts of country covered throughout with trees and shrubs, which, as a rule, are subject to special forest laws providing for their proper protection and other matters.

Although forestry has been practised in the United Kingdom for centuries, it did not receive much attention until the progress of forestry in India required the appointment of properly qualified experts, who could not be procured in this country. In 1864, Dr. D. Brandis (now Sir Dietrich Brandis, K C.I.E.) had been appointed the first Inspector-General of Forests to the Government of India, and that eminent organiser perceived at once that, if forestry in India was to be really successful and lasting, it was necessary to secure the services of an efficient staff to manage the extensive forests of our Indian Empire. First, two forest experts were obtained from Germany to assist Sir D. Brandis in introducing systematic forest management into India, and shortly afterwards arrangements were made to train a certain number of young Englishmen in forestry in Germany and in France. Then people began to ask why these young men could not be trained in this country, and thus the ball was set rolling. It could not, however, be denied that we had not the means of instruction, nor forests which had been systematically managed for a sufficiently long time to serve as training-grounds. Although our foresters are equal, if not superior, to those of any other country, as far as planting woodlands is concerned, there was no denying the fact that the management of the areas so planted left much to be desired. Only a limited area of forests is in the hands of the Crown, and these are held under peculiar conditions, while the bulk of the forests belongs to private owners, whose management is governed by considerations which may, and often do, change from year to year. Under these circumstances it was but natural that the Indian Government had its future forest experts trained where they were likely to learn most, and that was in Germany and France.

However, the matter was kept before the public, and for three years a Parliamentary Committee deliberated on the question "whether by the establishment of forest schools or otherwise our woodlands could be made more remunerative." The outcome of this committee was disappointing.

In the meantime difficulties had arisen in connection with the training on the Continent, and her Majesty's Secretary of State for India decided to start a forest school as a branch of the Royal Indian Engineering College, Coopers' Hill, where the candidates for appointments in the Indian Forest Department receive now their theoretical training. This took place in 1885.

Quite lately a course of instruction in forestry has been started in connection with the University of Edinburgh by Dr. Somerville, who has himself studied forestry at the University of Munich, in Bavaria. These matters have changed the aspect and position of forestry in this country, and it seems to me that I shall not be wasting an hour of your time by giving you a short account of the general utility of forestry, and of what is understood under the term, "the study of forestry."

I.—THE UTILITY OF FORESTS.

To enable us to judge of the claims of forestry, it is necessary to consider in what the general utility of forests consists, and in how far they become of importance in the case of any special country. Many pamphlets and books have dealt with the subject, and in many respects the most contradictory views have been advanced, especially as regards the indirect effects of forests. I have lately published the first volume of a "Manual of Forestry,"* in which I have given a summary of the utility of forests, in so far as it has been established by experience, up to date. In this place it must suffice to state that forests are of value through their produce and through the influence which they exercise upon the climate, the regulation of moisture, the stability of the soil, the healthiness of a country, and allied subjects. We all know that, besides timber and firewood, forests yield a great variety of other, or minor, produce, articles such as bark especially for tanning, turpentine, resin, caoutchouc, gutta-percha, catechu, numerous dye stuffs, flowers, fruits, fibres, grass, moss, peat, bamboos, canes, shellac, honey, wax, and many others. Most of these articles are of importance to the welfare of mankind in one way or another.

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* Published by Messrs. Bradbury, Agnew & Co., Bouverie-street, London, E.C.

Next, forests are important objects of indutsry, in representing a large amount of capital,* and because they provide work in a variety of ways, partly in connection with the administration and working of the forests, and partly in yielding the raw materials for an endless variety of industries. This part of the subject is one of special interest, but want of space prevents my entering more fully into it.

The indirect effects of forests are produced by agencies of which I may mention the following:—

(1.) The crowns of the trees, which interrupt the rays of the sun and the falling rain, obstruct the movement of air currents and reduce radiation of heat during the night.

(2.) The fallen leaves, flowers, and fruits, together with mosses, which grow in the half shade of trees, form a layer of mould, or humus, which protects the soil against changes of temperature, and influences the movements of water and air in the soil.

(3.) The roots of the trees penetrate into the soil and bind it together.

Owing to these agencies, areas covered with forest are subject to influences which do not exist on bare lands. As to the actual extent of the effect, views have varied considerably; some writers have been carried away by exaggerated confidence, while others distrusted the reality of the effects altogether. In more modern times, however, accurate and systematic observations have been introduced, not only in Europe, but also in India and other countries Such observation became of special value since the introduction, in 1867, by Professor E. Ebermeyer, of Munich, of so-called double or parallel stations, one being situated inside a fully-stocked forest, and the other at some distance from its boundary, in the open country; all other conditions, such as elevation, soil, &c., being, as near as possible, the same in both cases. The Indian observations do not, as yet, extend over a sufficiently long period to have yielded decided results, but those made in Germany, France, and Switzerland have settled many questions, while they have thrown additional light on others on which, as yet, final conclusions have not been possible.

As far as our knowledge goes at present, the following summary indicates generally the utility of forests in the economy of man and of nature:—

(1.) Forests supply timber, fuel, and other forest produce.

(2.) They offer a convenient opportunity for the investment of capital and for enterprise.

(3.) They produce a demand for labour in their management and working, as well as in a variety of industries which depend on forests for their raw material.

(4.) They reduce the temperature of the air and soil to a moderate extent, and render the climate more equable.

(5.) They increase the relative humidity of the air, and reduce evaporation to a considerable extent.

(6.) They tend to increase the rainfall.

(7.) They help to regulate the water supply, insure a more sustained feeding of springs, tend to reduce violent floods, and render the flow of water in rivers more continuous.

(8.) They assist in preventing land slips, avalanches, the silting up of rivers and low lands, and arrest moving sands.

(9.) They reduce the velocity of air currents, protect adjoining fields against cold or dry winds, and afford shelter to cattle, game, and useful birds.

(10.) They assist in the production of oxygen and ozone.

(11.) They may, under certain conditions, improve the healthiness of a country, and under others endanger it.

(12.) They increase the artistic beauty of a country.

Although forests may be useful in a great variety of ways, it depends on the special conditions of each country whether they are necessary or even desirable. No general rule can be laid down in this respect. As regards the direct effects of forests, it is necessary to consider the position of a country, its communication with, and the control which it exercises over other countries, the quantity and quality of substitutes for forest produce which are available in the country, the value of land and labour, the returns which land yields if used for other purposes, the density of population, &c. Since these matters differ from place to place, it follows that the forest policy of various countries has taken different shapes. Thus it has been brought about that at the present moment the forest area in the countries of Europe ranges from 4 per cent. of their total areas to 48 per cent., namely:—

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* The woodlands of the United Kingdom may be estimated to represent a value of not less than £100,000,000. The forests of Germany are valued at £1,000,000,000.

United Kingdom	4 per cent.
Holland	7 "
France	16 "
Norway	25 "
Germany	26 "
Hungary	29 "
Austria Proper	33 "
Sweden	42 "
Russia	42 "
Servia	48 "

Even a superficial consideration will show that Great Britain, with its extensive coal-fields, iron industry, seabound situation, minute system of railways, and moist climate, does not require as much forest as, for instance, Russia, which is subject to conditions of an almost opposite nature, or even Germany, as long as the necessary timber can be obtained at a reasonable rate from other countries. Whether the latter will be always practicable is, however, by no means assured. During the years 1883-87, for instance, we have imported nearly 6,000,000 loads of timber every year from the following countries:—

	Loads.
Russia (northern ports)	1,333,139
Sweden	1,506,852
Norway	728,111
Germany	346,189
France	348,771
The United States of America	373,089
Total	4,636,151
Canada	1,233,516
Grand total	5,869,667

Of this material about four and a half millions were from countries over which the British Government has no control; and even as regards the colony of Canada it can only advise. It follows that these sources of supply may fail either from a gradual exhaustion of the forests or from political reasons. Now, all the timber included in the above figures is of such a nature that it could be replaced by timber grown in these islands. It is also a fact that the United Kingdom contains an area of 26,757,000 acres of barren mountain land, bog, marsh, waste land, &c., of which a considerable portion is fit to produce timber, and it has, consequently, been urged that such lands should be brought under forest. The difficulties which face such a scheme are no doubt great; the lands in question are private property, they are in many cases required for grazing purposes, the creation of forests requires a certain outlay, and they would not yield any substantial return until after a considerable lapse of time. Moreover, the present prices of timber are very low, whereas waste lands let as shooting grounds give immediate and very often substantial returns.

And yet a good deal could be done towards increasing the area of our forests, without interfering with present returns to any appreciable extent. To proceed in a wholesale fashion in such a case is always courting failure at the very outset. On the other hand, the returns from many of the estates could be considerably increased by putting the better parts of the land under wood.

Only a few months ago, I passed over an extensive tract of land which is now let for deer shooting, at an annual rental of £2,000. On inquiry, I found that the area included in the lease amounted to about 30,000 acres, so that the owner received about 1s. 4d. per acre a year, which is, after all, not a very high return. A good portion of the land was situated above the upper limit of profitable tree growing, but a big slice contained unmistakeable signs of having once been a very fine Scotch pine forest. Indeed, I saw there the biggest Scotch pine tree which I have ever seen. Now this land could be made to yield a great deal more than 1s. 4d. per acre, if stocked with Scotch pine, an operation which, if done judiciously, need not reduce the rental from deer shooting. I have seen many other similar cases in Scotland, where the yielding power of estates could be considerably increased if their management was approached in a somewhat more enlightened manner.

Other seabound countries are, in many respects, situated as Great Britain, and the forest question is not pressing. In the same degree, however, as we proceed from the Atlantic Ocean in an easterly direction to the continental countries, matters change. The same extensive coal-fields and means of transport are no longer available, and the necessary forest produce has to be grown on the spot. At the same time the climate becomes less moist, the rains are less favourably distributed over the year, extremes of temperature become more pronounced, and the indirect effects of forests more important. In consequence of these conditions, continental countries, more particularly Germany, recognised the importance of maintaining a certain proportion of the land under forest at a comparatively early time. In that country systematic forestry, as now understood, was introduced with the commencement of the present century, passing over here the more incomplete measures taken at earlier periods. The rise of the scientific and systematic treatment of the forests in Germany was principally inaugurated by three men—Hartig, Cotta, and Hundeshagen—who were followed by quite a host of others up to the present day. The result of their labours is, that in no country of the world are forests treated in an equally efficient manner, and other nations had from time to time to go to Germany to learn what really successful forest management implies. In Germany, an area of 34,350,000 acres, equal to 26 per cent. of the total area, is at present under forest. Of this area, 33 per cent. belong to the State, 19 per cent. to corporations and endowment funds, and 48 per cent. to private persons. The former two, or 52 per cent. in all, are under the direct control of the State authorities, while the private forests are subject to supervision in as far as they affect the welfare of the general community.

And here I may say a few words about State interference in the case of forests. Where forests are not essential on account of their indirect effects, and where the importation of the necessary produce from other countries is easy and assured, the State, as such, need not, as a rule, take measures to maintain or acquire forests, but where they are required on account of their climatic and mechanical effects, and where importation is uncertain or impracticable, a wise administration will take measures to insure the maintenance of a suitable proportion of the area of the country under forest, either by constituting a certain area of State forests, or by controlling the management of corporation and even private forests. In the case of the latter, interference is only justified when the welfare of the general community requires it.

This case has, up to date, not arisen in these islands, hence such interference has not been introduced by law, and seems repugnant to the mind of an Englishman. In continental countries matters are different, and if there the State did not interfere, timber and firewood would in many cases reach prohibitive rates, or become altogether unprocurable. The extent to which such interference is carried depends on the special conditions of each country. Suffice it to say that it is exercised in most continental countries. India has followed a similar policy during the last 30 years, and the matter has of late attracted the attention of the Governments of many of our colonies, with what effect I propose to show in another place.

As the consequence of all this, the study of forestry has received a powerful impetus in this country. And this brings me to the second part of my task.

II.—The Study of Forestry.

Forestry ascertains the principles according to which forests should be managed, and applies these principles to their treatment. The first part is called "forest science," and the latter "practical forestry."

As forests occupy a portion of the land, it follows that forestry really forms part of agriculture in its widest sense; it is essentially an "industry." As long as the land of a country is valueless, or nearly so, this is not felt; but in the same degree as the value of the land rises, the industrial character of forestry becomes more and more apparent, and in the more civilised countries, especially of Europe, forestry is expected to teach how forests should be managed, so as to realise, in the most advantageous manner, the objects for which they are maintained. Now, this opens up the whole question: "The objects for which forests are maintained." What are these objects? The answer is a long one, but it may perhaps be condensed to the following points.

(1.) The object of maintaining a forest may be to yield produce of a definite description; for instance, trees which give a certain class of timber or other produce fit for particular purposes, or trees and shrubs of special beauty.

(2.) In other cases the object may be to produce the greatest possible quantity of wood or other produce per acre and year; for instance, a proprietor requires annually a certain amount of timber and fuel for his estate, but does not wish to set aside for this purpose more area than he can absolutely help; in this case the management would have to be so arranged that each acre yields the highest possible quantity of produce.

(3.) In other cases the owner desires to derive the highest possible annual income from his land.

(4.) In other cases the owner seeks to derive the highest possible interest on the invested capital, cases by no means identical with those mentioned under (3), because the different methods of treatment require different amounts of capital, and yield different returns.

(5.) In many cases the object is to produce certain indirect effects; for instance, to influence the climate of a country, to regulate its drainage, preserve the stability of the surface soil, prevent landslips, sudden floods, the silting up of low lands, the formation of avalanches, afford protection against cold or hot winds, &c.

Now each of these, and many other cases, demands a distinct method of treatment, and probably also the growing of particular species of trees; but the matter does not end here. An essential point of rational forestry is not to injure the permanent value of the property in realising the particular object of management. On the contrary, the management should be so arranged that the present generation takes only its proper share, nor should future generations be favoured at the expense of the present; in other words, the land should be made to yield now as much as it can, without endangering its yield capacity in the future.

It is the business of the forester to deal with all the questions involved in the above-mentioned matters. There are people who understand, under a "forester," a man who goes about with a heavy axe over his shoulder, and a couple of pruning instruments by his side, ready to cut and to prune as he goes along, and who, at certain times of the year, plants young trees where old ones have been removed. Such a man is no doubt a forester, in fact, a practical forester or woodman. At the same time, the State or other large owner would be very foolish to entrust the decision of all the intricate questions on which I have touched to a man of that class. To deal with the questions of forest policy generally, and to devise the system of management applicable to forests under varying conditions, requires something more than the capacity to swing an axe and to plant a tree. An expert who can be safely left to deal with these matters must be skilled not only in practical forestry, but also in forest science; and the question now before us is, what does this imply? Well, it means that a forest expert requires, in the first place, to be an educated man, with a well-trained mind. But this is not enough; he requires also a knowledge of special branches of learning. He must be acquainted with the elements of law and of political economy, so as to judge of the provisions of the forest laws, and understand forest questions in so far as they concern the welfare of the State as a whole. Next, he must be acquainted with chemistry and physics, or else how could he understand geology, mineralogy, zoology, and botany, which form the very foundation of his business? One of the principal requirements of a forest expert is to understand the effect of soil and climate upon forest vegetation, and *vice versâ*. For this purpose, he must be acquainted with the chemical and physical qualities of the soil, with the factors of the climate, heat, light, the movement of moisture in nature, the law of air current, &c. Then, botany in all its branches is indispensable, because the forest expert must not only be capable of determining the various constituents of forest vegetation, but he must also understand the mode of growth of trees and plants, and the diseases which plants, especially fungi, bring to trees. And last, but not least, he must understand entomology, which deals with the insect enemies of forests.

Having enumerated all these things, I have, after all, only arrived at the threshold of forest science. In fact, the branches of learning mentioned above are, from this point of view, generally called the "auxiliary sciences." Forest science proper is generally divided into two main branches; the first of these teaches how to produce forests, and the second how to manage them.

"Forest Production" may be divided into the following four sections:—

(1.) Locality in relation to forest vegetation.

(2.) Sylviculture, or the creation, regeneration, and rearing of woods, until they become ripe for the axe.

(3.) Forest protection, which teaches how forests may be protected against man, animals (especially insects), plants (especially fungi), climatic influences, natural phenomena, &c. Such protection is afforded partially by laws passed by the Legislature of the country, but chiefly by appropriate measures taken by the owner of the forest.

(4.) Forest utilisation, which deals with the technical qualities of timber; consumption of wood; the felling and shaping of trees; the disposal and transport of wood; the harvesting of other forest produce, such as litter, grass, fruits, bark, turpentine, caoutchouc, dyes, fibres, &c.; the impregnation of timber, forest saw-mills; manufacture of charcoal, &c.

The second branch "Forest Management," deals with all the parts of forest science which influence the management, and of which I may mention:—

(1.) Forest policy, or consideration of the objects of management. This branch is based upon statistics, and it necessitates the elaboration of a method by which the interest derivable from the invested capital and the yield capacity of estates can be readily ascertained.

(2.) Forest organisation, or the principles according to which the general management of forest estates should be arranged.

(3.) Forest mensuration deals with the determination of the volume (or cubic contents) of trees and woods, their age, past and probable future increments.

(4.) The working of forests. Here the yield is ascertained and plans drawn up, which regulate the due execution of all forest operations, such as final cuttings, thinning, pruning, planting, and all other works, and all this in strict accordance with the objects of management.

The mere enumeration of these branches of study shows that forest science is a superstructure erected on the basis of many other branches of learning. Forestry is, however, also based upon empirical knowledge; hence the study of forest science, if it is to be fruitful, must go hand in hand with practical instruction in the forest; in other words forest science and practical forestry must go together, neither the one or the other by itself makes a forest expert. In the same way as the medical student walks the hospitals while he hears lectures on the various branches of medical science, so must the forest student walk the forest as a necessary supplement to his studies in the class-room.

The importance of employing really competent men in the management of forest estates, whether belonging to the State or to private owners, has led to the establishment of forest schools in most European countries. There are nine such schools in Germany alone, some forming part of universities, others being attached to higher technical schools, and some being independent institutions. Most of these are first-class schools, where the instruction is given by a considerable number of professors. To show the position which they take, I may mention that last year the principal Professor of Forestry at Giessen, Dr. Hess, filled the post of honour of Rector of the University, and this year Dr. Gayer, Professor of Forestry, holds the same position in respect of the University of Munich. The fact is, that in Germany the Forest Department holds the same rank as other branches of the administration, and a Forest Officer, who has gone through the prescribed course of education, is eligible for, and actually does reach, according to eminence, the highest posts in the *ressort* of the Ministry, to which the Forest Department belongs. I must, however, add that the standard of education is on a par with that of the other branches of the administration, and it takes a forest student, after leaving the grammar school, about six years to qualify finally for the upper branch of the service. France has a first-class forest school at Nancy, and the forest service of that country stands on a footing similar to that which it enjoys in Germany.

Turning now to this country, we find at present two places where scientific forestry can be studied. As already mentioned, Dr. Somerville has commenced instruction in connection with the University of Edinburgh. The undertaking is quite in its infancy, and I am not in a position to say much about it. Dr. Somerville is now giving his first course of 100 lectures, in which he proposes to deal with certain chapters of botany and forestry. His principal difficulty is due to the absence of systematically managed forests in Scotland, where the theories taught in the class-room could be sufficiently demonstrated. As far as I am aware, the Scotch forests now in existence belong all to private owners, whose forest policy depends chiefly on the following considerations:—

(1.) The æsthetic effects of their forests.

(2.) The state of their exchequer.

(3.) The returns which their lands are capable of yielding, if used as shooting grounds.

(4.) Family considerations—whether the forests go, at the death of the present owner, to his own children, or some other branch of the family.

It is against human nature to expect systematic management extending over long periods, as long as the estates are subject to such considerations. At the same time it will be a difficult task to bring about a change in these matters.

The Forest School at Coopers' Hill was

established in 1885, and it forms part of the well-known Royal Indian Engineering College at that place. The whole institution belongs to the Government of India, and is consequently under the orders of her Majesty's Secretary of State for India in Council. The President of the College is General Sir Alexander Taylor, G.C.B., R.E. We commenced in a modest way, and gradually developed the establishment. Hitherto the course of instruction has comprised 26 months, but it has now been decided to extend it to three years.

According to the requirements of the Indian Service, a number of young men (twelve at present) are selected annually by means of a competitive examination held by the Civil Service Commissioners. They must be British-born subjects, over 17 and under 20 years of age. The entrance examination will in future be arranged on the same lines as the so-called "Further Examination" for admission to the Royal Military Academy at Woolwich. There will be only three obligatory subjects, in which each candidate must satisfy the Commissioners, namely—English, German, and mathematics (arithmetic, algebra, euclid, plane trigonometry, mensuration, and elementary statics and dynamics). For the rest each candidate may chose a maximum of three subjects from amongst the following:—Higher mathematics, French, Latin, Greek, English history, chemistry, physics, physical geography, and geology. Over and above these, he may take up English composition, freehand drawing, and geometrical drawing, if he chooses to do so.

The object is to enable young men, who have passed through one of our first-class schools, to compete successfully without extra preparation by a special establishment.

The successful students enter the college in September, and of the time set apart for instruction, two years, or six terms, are spent at the college, and the last or seventh term, on the Continent. Under the revised arrangement, which is expected to come into force this year, the students will spend eight terms at the college, and be instructed in the following subjects:—

By the Staff of the Engineering Branch of the College.

1. Inorganic Chemistry.
2. Physics.
3. Geology and Mineralogy.
4. Accounts.
5. Surveying.
6. Road Construction.
7. Drill and Gymnastics.
8. Geometrical Drawing.
9. Freehand Drawing.
10. German.

By the special Professors of the Forest Branch of the College.

11. Chemistry of Soils and Vegetation.
12. Entomology.
13. Botany.
14. Forestry.
15. Elements of Law and Political Economy.

In subjects 1 to 7 the instruction is the same as that prescribed for engineering students. The instruction in geometrical drawing ceases at the end of the second term. In freehand drawing and German extra instruction is provided.

The instruction in chemistry of soils and vegetation is at present given by Professor A. H. Church, M.A., F.R.S.; the instructor in entomology is W. F. H. Blanford, Esq., M.A.; for botany we secured from the beginning Professor H. Marshall Ward, M.A., F.R.S., F.L.S., whose eminence in this branch is well known. The instruction in botany extends over elementary biology, organography, anatomy, systematic botany, physiology, and pathology; it comprises about 170 lectures, with work in the botanical laboratory, excursions to the country surrounding the college, and regular visits to the Kew gardens and museums.

For the instruction in the elements of law and political economy we hope to secure the services of a retired member of the Indian Civil Service, who has written an excellent work entitled, "A Manual of Jurisprudence for Forest Offices."

The instruction in forestry has, up to date, been given by me; it is now contemplated to engage a second professor of forestry, and to double the amount of instruction hitherto given. The instruction extends over the several branches indicated above, and will comprise, under the revised arrangement, about 280 lectures, supplemented by practical instruction in our forest nursery in the adjoining Windsor forests, visits to more distant forests, such as the Esher oak forests, the beech forests around High Wycombe (in the centre of the chair manufacture), the New Forest, Forest of Dean, and High Meadow Woods, and the forests of several noblemen in Scotland. Amongst the latter those belonging to His Grace the Duke of Athole, the Earl of Mansfield, the Countess Dowager of Seafield, and Lord Lovat have, of late years, been regularly visited in the autumn; on these occasions we also visited the large nurseries of Mr. Gossip at Inverness.

As already indicated, the practical instruction cannot at present be completed in this country; hence at the completion of the course at the college the students, who have qualified in the various subjects of study, proceed to the Continent, where they are taken charge of by Sir Dietrich Brandis, who, during a period of not less than three months, takes them to a number of the most interesting forest districts in Germany, Switzerland, and Austria, where they study the management of forests, which have been under systematic treatment for a long period. I need hardly add that our students could not be in better hands. Sir D. Brandis possesses not only a vast store of knowledge, but he also insists on the students making full use of their opportunities.

This brings the instruction to a close, and the young men proceed then to India to take their place in the Forest Department of that country.

We have established at Coopers' Hill a forest museum, a botanical and entomological laboratory and a forest nursery, besides the already existing chemical and physical laboratories. By the kindness of the Commissioners of Woods and Forests we are placed into direct communication with the Deputy Surveyors of the Crown forests, who do all in their power to assist us. The Windsor Crown forests are within easy reach of the college, and they afford most excellent means for the study of forest botany and arboriculture. As to the study of sylviculture, they are, however, not adequate to our requirements, for reasons which are due to the objects for which these forests were maintained, a subject upon which I need not enter here. Suffice it to say that there is a sufficient area of forest land outside Great Windsor Park for the purposes of instruction, and we are now in treaty with the Commissioners of Woods and Forests, with the view of an area of 1,000 acres being made over to our management, and of their gradual conversion into a proper training ground for forest students. I have every reason to believe that an agreement will be come to at an early date.

And here I may add a few general remarks on this subject. As long as we have not a sufficient area of forests in this country which has been subject to systematic management on economic principles for a considerable period, our forest students must go to the Continent to see and study the management of such forests. But it seems to me that, considering the importance of the matter to India, our vast colonies, and the mother country itself, we should not lose another moment to put certain forests in this country under systematic management, and to make sure that they continue to be so managed. It would be hopeless to expect private proprietors to do this, and we naturally turn to the areas at the disposal of the State. Now, there are certain areas under State management, the so-called Crown forests. They do not, however, belong to the State, but to the Crown, and consequently they are not altogether at the disposal of the former. In the general interest of forestry, however, an effort should be made to secure suitable parts of the Crown forests for our purpose, and I do not see why this could not be arranged. The management of these woodlands proceeds now on special lines, and the Commissioners of Woods and Forests, though ready to meet our requirements, will only do so by being paid for it, because they plead that they are expected to make the most of the estates. They put a high price on their land, because they count on its being taken up for building purposes.

While admitting that nothing can be said against the views of the Commissioners from their own point of view, I think the State, as such, should take a wider view of the matter, and arrange for the management of a suitable selection of areas, with the view of their becoming patterns of systematic forest management. Such a step would doubtlessly be of great benefit, not only to the mother country but also to India and the Colonies. And what is more, it could be done without in any way reducing the income now derived from such lands; on the contrary, these forests would gradually become more valuable and yield an increasing return. The areas so treated would be available for any forest school which may be started in this country; but as Cooper's Hill is most favourably situated in respect of suitable Crown lands, it would be as well to develop the already existing school and to adapt it for the requirements of students who propose going to the Colonies, and for forest experts who desire to work in this country. Such students, if sufficiently grounded in the auxiliary sciences, need not necessarily go through the three years' course prescribed for Indian students; shorter courses suited to their requirements could easily be arranged with a comparatively small additional outlay.

Pending a further development of the college in the direction indicated above, I may mention that under present arrangements students not nominated for the Indian forest service are received at the college, as far as the available accommodation permits. Such students may pass through the course of instruction prescribed for the nominees of the Indian forest service, or they may be permitted to participate in the instruction given in certain subjects only. On attaining a prescribed standard, the students will receive, according to circumstances, either the college diploma in forestry, or special certificates showing in what subjects they have followed the instruction, and with what result. Students of the latter class will be required to abide by the general rules of the college, but they are not obliged to reside in it. If they elect to live outside they will only pay for instruction according to the subjects which they take up.

Thus it will be seen that we have the nucleus of an institution, which only awaits the full support of the Colonies and of the mother country, to develop into an institution worthy of the best forest schools on the Continent. There is no reason why such an institution should not be self-supporting. At any rate, the contribution on behalf of the State would be infinitesimal if compared with the interests, which may be endangered if the forests of the British Empire are left uncared for, or their management is entrusted to hands which are not competent to do justice to them.

This completes the remarks which I propose to offer to-day. I trust that I have succeeded in demonstrating the importance of employing only fully competent forest experts in the management of forest estates which are treated on economic principles. Competition has become so acute in these days, that the area of mere landscape woods is becoming more and more contracted, though the two objects can, to a considerable extent, go hand in hand. As to our Indian Empire and many of our colonies, the maintenance of a sufficient area of forests has clearly become the duty of their Governments. India has recognised this duty some time ago; most of our colonies are, however, still playing with the question. Let us hope that they will awake to real earnest work in this direction before it is too late. It takes a long time to grow a tree, but a short time to cut it down; hence foresight and continuity of action are of greater importance in the case of forestry than in almost any other branch of industry.

DISCUSSION.

Sir Charles Bernard, K.C.S.I., said this very interesting paper had shown conclusively that the maintenance, improvement, and proper administration of forests were of very great importance to any country. Most of those present being specially interested in India, held the strongest views about the utility of the Indian forests, and the desirability of administering them to the best advantage for future generations through the agency of a well instructed department, meeting under the executive government of the country. In India there were laws for each province under which the forests were arranged, and probably the whole area of the empire under forest was about 15 or 16 per cent. of the whole, but at present the area of forests under Government management was not more than about 8 or 9 per cent. The forest administration in India began many years ago under the auspices of the Chairman; it had been carried on by Sir D. Brandis, and next to him in the history of Indian forestry came the name of Dr. Schlich, who, carrying on the work of Dr. Brandis, had organised the Forest Department as it now existed. The total revenue, which began with nothing, was now nearly 1½ million sterling per annum, and the net revenue was nearly half a million sterling; a very good result. At first a great deal of apprehension was felt by some of the natives and others that the taking over of these large areas by the Government would operate to the injury of those who lived near and who had certain rights of use in them; but as Dr. Schlich had told them with regard to the German forests, the amount of employment afforded in various ways by the proper management of these forests was very large; and though this did not operate to so great an extent in India, still the State management of these forests supported a large population in much greater comfort than they had enjoyed forty years ago, when the forests were under the management practically of no one at all. At the present time the forests were used partly as grazing grounds and partly as timber-producing areas; in every case, those who grazed cattle or cut timber paying a little for the privileges they enjoyed. Formerly some paid a little, but most did not, and those who paid did so not to the State, but to those who had in one way or another possessed themselves of the forest areas. There were still considerable forests in Bengal and other provinces, the property of private persons, which were now being exploited in a most wasteful way, and before another generation they would probably be improved off the face of the earth, and then there would only remain the State forests under the management of the department constituted by Dr. Brandis and Dr. Schlich. He had been much interested in the account Dr. Schlich had given of the School at Coopers' Hill, some pupils from which had already gone out to India, and he could testify that they were an admirable set of young men, and he hoped that the example thus set would be followed both in the Colonies and in the mother country, so that the important subject of forestry should receive due attention.

Mr. B. H. Baden Powell, C.I.E., said there were two points not yet mentioned which he thought worthy of notice. He hoped this paper would not be considered as an Indian paper, though it was read before the Indian Section of the Society. It was a general paper, not confined to Indian forests, and if it served to call the attention of the Colonies to the matter, it would do a great work. To those who had been in India and knew the importance of managing forests on a systematic scale, it seemed perfectly amazing that in none of the most important colonies did any forest laws exist. His own experience had been mostly in connection with forest legislation, and matters connected with rights in forests, but amongst all the laws sent him for review, with the exception of some slight regulations in Cape Colony, there were no laws at all relating to forests. He had never seen such in any of the Australian States, nor in Canada, which ought to be the most important forest country in the world. This was a most astonishing fact, but it would only become astonishing to the public when the utility of forests was thoroughly understood, and if this paper only had the effect of arousing public attention to the immense importance of properly managing the colonial forests, it would be most useful. The other remark he wished to make was this. A few years ago it was more common than it was now—though it was not entirely unknown still—to hear remarks made by some people on the selfishness of Governments in shutting up large areas of public forests, as if the Government got some personal benefit, and did not manage the forests for the public benefit. It was said that the effect of forest conservancy was to deprive the poorer inhabitants of grazing their cows and goats, and of doing all the little mischiefs which they loved to do in forests. But that was a great mistake; if a forest were properly conserved, it did not diminish the legitimate satisfaction of the requirements of the villagers and other population, but, on the contrary, absolutely increased that enjoyment. If you gave a child a whole cake, it would make itself sick, and destroy the cake in a very short time. It was just the same with a village; if it managed its own forest, it set fire to the grass, in the vain idea of getting a crop of young shoots for its cattle; it cut down a young tree when a ploughbeam was wanted, without thinking that if it were left for a few years, it would be fit for something else; the whole forest was wasted, and, in a few years, disappeared, and then the people went to the conservators of the next forest, and begged for the privileges which they no longer possessed in their own. If the Government insisted on having the forests properly managed, and if they gave out the cake slice by slice, it was much more wholesome, and lasted longer.

Sir Joseph Fayrer, M.D., K.C.S.I., F.R.S., confessed to some little disappointment at not hearing, as he had expected, something about the present condition and progress of the great Indian forests, but at the same time the paper was a most excellent one on the general subject. This was the first time he had had an opportunity of listening to a scientific expert speak on the subject of forestry, and he was glad to hear what he had said as to the steps which were being taken to train a set of scientific foresters; he hoped, however, they would not be too scientific, or encumbered with too many examinations, or when they got to India they might be so exhausted that the forests would not benefit much by their aid. His own opinion was that if they were thoroughly educated in the first instance, and instructed in the elements of chemistry and botany, with perhaps one or two other branches of science, it would be quite sufficient. He believed that under the guidance of Dr. Schlich and his colleagues they might attain in this country, at least sufficient elementary knowledge to enable them to start in India, where, after all, the real work of their life lay. As Dr. Schlich had said, when they arrived in India they were not experts—how could they be in so short a time—but they ought to be thoroughly trained in the elementary branches of knowledge, so that they might be able to put their knowledge into practice when they got to India. Few people realised how much they were indebted to those distinguished men, General Michael and Dr. Cleghorn, who had been the pioneers of forestry; and still less did they appreciate how much India owed to the Forest Department, or recognise how much the health and material prosperity of the country were affected by the growth and development of the forests. It would be presumptuous for him, before such an audience as this, to state the various reasons why forests should be encouraged, or attempt to point out what had been the effect on countries in which this culture had been neglected. Palestine, Greece, and many other countries where deforesting had been allowed to go on were examples, and their present condition compared with that of past times would give some idea of what the neglect of forestry implied. The same thing might be seen in many parts of that great country with which many present were familiar. In desert regions of the north-west of India rivers had disappeared—sunk into the sand—and populous states had vanished as a result to a great extent of the annihilation of forest growth in those countries. They had heard of some of the influences of forests—a cooler and more temperate state of the atmosphere, a better supply of ozone. There was a familiar example in that great belt of low forest land called the Terai. Some said, "Cut it down, because it is malarious and kills people." So it does, but for every one it kills, it probably saves thousands in other ways, through the influence of the trees and the vegetation. Those trees sent their roots into the ground, and under their shade were developed the lower forms of vegetable life. These roots prevented the too rapid draining away of the water; but for this the water which fell on the south of the Himalayas would rush away in torrents, denuding the rocks, instead of being gently diffused, as now, under the favouring influence of these trees. No one knew better than their Chairman that, on approaching this great forest region in the month of March or April, when the heat was intense, when you approached the Terai, long before you got into the forest you found a comparatively cool atmosphere. This was owing to the presence of the vegetation which so many would cut down, but which he hoped would be maintained. This was merely an illustration of one of many sanitary reasons why forests should be encouraged, and there were many others. He had no special knowledge of forestry, but took a great interest in it from sanitary considerations, and he believed there was no department from which the Indian Government might look for better results than the one whose cause had been advocated that evening, and for the founding of which India owed much to the Chairman.

Mr. W. SMARTT suggested that before students of forestry went to India it would be well if they gained some knowledge of the various products which were sent home from that country, many of which came forward in a very imperfect condition. It would also be well if they obtained some knowledge of the timber trade in London. It was a great pity that some one of more skill was not employed in Epping Forest, for instead of allowing the young trees to grow, many had been cut down, and the old pollards were allowed to remain, apparently to give a more picturesque appearance to the landscape. This might improve present appearances, but it resulted in a serious future loss. A large portion of Central Australia had no trees, and it would be an enormous advantage if the Government of that colony could make arrangements for planting it. Of course they would be planting for the future, and the cost of planting a large tract would be very great, and therefore the whole of the Australian colonies ought to unite in the work.

The CHAIRMAN said Dr. Schlich had given his views very clearly with regard to the utility of forests, and the education required for a forester of the higher grade; that of a lower grade of woodmen, such as would be required in England, would naturally follow. No one who had visited the great forests of Germany, Austria, and France could fail to be struck with the visible effects of good management, and he wished the same effects were more generally apparent in this country. For his own part, he seldom went through a wood or plantation in Scotland or England without wishing he could have something to do with it for a few years. But there were signs that the subject was now attracting far more attention than it did, and there was a better chance of a good practical training for young men wishing to make forestry their study. He ventured to predict that, before many years were passed, Dr. Schlich would have a large number of students at Coopers' Hill, destined for home employment and not for India only. It augured well for their future that they should be in such good hands. Personally he knew more about forestry and a forester's life in India than elsewhere, having spent seven or eight of the happiest and, perhaps, the most useful years of his youth as a forest officer; that was more than forty years ago, before the time arrived for experts like Dr. Schlich or his distinguished predecessor, Sir Dietrich Brandis, to come to the front. He could therefore tell any young men who were thinking of taking up this career that it was not only a most important one, but one full of interest, and of positive enjoyment. The formation of the Department in which they would serve—and in which Dr. Schlich served so well and successfully—had been justly characterised by Sir Richard Temple as one of the greatest achievements effected in India during the reign of Her Majesty the Queen. He concluded by proposing a hearty vote of thanks to Dr. Schlich.

The vote of thanks having been carried,

Dr. SCHLICH, in responding, said he need only refer to one remark of Sir Joseph Fayrer's, as to the undesirability of teaching the students too much. That idea commended itself to many people, but he had always understood that knowledge is power, and that it was very difficult to teach a man too much. These young men who were trained at Coopers' Hill were to recruit a staff of 180 superior officers who had under them a staff of 12,000 forest officials, and if those who were to arrange for the management of the forests and to guide the whole concern were not thorough experts, he failed to see how those who were under them could be expected to do the right thing. He did not think, therefore, that they could be taught too much of their profession.

APPLIED ART SECTION.

Tuesday, February 11, 1890; H. H STATHAM, F.R.I.B.A., in the chair.

The paper read was—

CAST IRON AND ITS TREATMENT FOR ARTISTIC PURPOSES.

By W. R. LETHABY.

"From that one surrender of its integrity, from that one endeavour to assume the semblance of what it was not, arose the multitudinous forms of disease and decreptitude." —*The Lamp of Truth.*

"The value of every work of art is exactly in the ratio of the quantity of humanity which has been put into it, and legibly expressed upon it for ever."—*The Stones of Venice.*

The word "art" embraces in its wide reach everything added to the work of man for order's sake, for fitness, and for beauty; from high invention, passion, and stimulating thought, to the decencies of mere custom and habit. It would seem that man's labour, and indeed his life, must be seasoned with this salt. We cannot imagine a shirt sewn, a doorstep whitened, or a table laid, without some care and contrivance for enjoyment, over and above the mere needs and necessities of the moment; and every calling of any ancestry at all, shaped by use and observance, from war to agriculture, is made sightly and beautiful by the ordinances and traditions of it, so that they are unthinkable without art. Truly, as Mr. Ruskin says, "Life without art is brutality;" for mere labour is chaotic and destructive of manliness: without this tribute to Nature's order and man's own self-respect, it numbs and atrophies the sensibilities. Art is a debt we may say we owe to material, the seal that alone makes a thing worthy to exist.

Too many of our industries have fallen out of the categories of arts into mere "production," as it is called, wanton and careless of other ends than immediate profit.

Now this art of iron-founding has interested me because, on this hand, it is one of our vastest resources, national in its importance; and on the other hand, degraded and scorned, it has become a commonplace of cant to decry it; until, for the most part, it has become worthy of the disdain. But art is universal; to give up one corner of the field is to destroy the fair harvest; it, it is which plaits the straw finial on the wheat stacks of the homestead as well as points the proudest steeple. All materials are alike, if not equally, vehicles for its expression; each one of which can give us something simple and alone, something without which the world suffers lack.

In the notes that follow I do not propose to speak of the metallurgy or manufacture of iron, in both of which I am sufficiently ignorant. I want, rather, by an examination of specimens which I think beautiful or suggestive, to arrive at what—to borrow Mr. Pater's word—we will call an "appreciation" of the metal, and certain methods of manipulation. For me, therefore, the primitive apparatus of the East for obtaining iron—a few stones and clay for furnace, a goat skin and bamboo for bellows, and charcoal for fuel—producing the wonderful watered blades of swords: or daggers, inlaid with purple gems like the stain of a death-blow: or those in which rubies run like red drops of blood along a groove to the point. Such apparatus is more for my immediate purpose than the towns of fire and sulphur which produce—what?

The easy contempt we feel for iron is the direct result of our treatment of it for gain and not for true service. Yet sentimentally—and all art has to find out the intrinsic sentiment of phenomena and so interpret them in an exalted form—there is a certain mysterious appeal in iron only surpassed probably by the gold of the poets with its red bloom: and so pure as to be "soft as wax;" barbarous, occult, and fateful.

Iron, on the other hand, stands for strength, simplicity, even severity, and, on its sinister side, for cruelty and terror. In the old apportionment of the seven metals to the seven planets iron belongs to Mars, as gold to the sun and silver to the moon; and Chaucer rears his temple of Mars on iron pillars of the diameter of a barrel and polished.

> "Every pillar the temple to sustain
> Was ton-great, of iron bright and shene.
> There saw I first the dark imagining
> Of felonie, and all the compassing."

Dante too builds of it, . . . "the moats profound. That circumvallate that disconsolate city." We are not conscious of any mean reflection or association, but rather an exaltation of the imagination, when, in the curious myth of Mahomet's coffin, we are told that it was of iron, sustained in the air by the equal attraction of the walls, ceiling, and floor, which were of loadstone: or in another eastern tale, "The City of Brass," where it says that an inscribed tablet of iron of China was suspended in front of the "Terrible Tomb;" we feel that bronze or even gold would be an anti-climax. In the image interpreted by Daniel, iron stands for power, "Strong as iron: forasmuch as iron breaketh in pieces and subdueth all things," and "wherein (as says the Koran) is mighty strength for war." To come to actual instances. When in the fourth century a great Indian Raja set up the pillar of Delhi at the true centre of the round world, to commemorate, as the inscription reads, having "obtained with his own arm an undivided sovereignty over the earth," the great shaft of iron was made which, still undecayed, forms one of the oldest of Indian records. The iron crown of Lombardy, or the cross of Germany, are further instances in which the mere name of the metal lends a mysterious and moving import of invincible sternness.

The highest art is to concentrate the powers for one premeditated appeal to stimulate the imagination, and for this the quality of inherent sentiment of the material is not the least of the formative factors; as the Egyptians knew well when they selected black basalt for their statues; and the Hindus, again, when in some of their temples they used great beams of iron, not as mean, but precious things. And Pliny, when he tells us of a certain statue of cast iron, says that it was chosen as appropriate to the subject—a Hercules.

As our sensibility widens, and deepens, we shall find that not a given material—the whitest marble, or greenest bronze are necessarily artistic—but the intellectual or intuitive grasp by which material and motive, texture and technique, are made to co-ordinate in one balanced and adequate result. And thus stern iron might offer, in the hands of a master, a material of great value in serious and commanding work; indeed, on the plane of the highest sculpture, we can only think one man's work into iron, and that man the greatest artist of them all. We might, perhaps, be allowed to recommend to the rising new school of English sculpture sometimes to think away from the, perhaps, petty prettiness of bronze, to *think* sometimes in iron.

Having once made this claim for iron to a place in serious art, my actual examples will be of much lower range and humbler intention. Waiving this possibility of the highest appeal, and selecting iron because of its commonness and powers of resistance, it has been treated as an art "not too great and good for human nature's daily food," but still an art real of its kind. By a careful selection of the forms and treatment suited to the structure and texture of the material, and its application to commonplace needs, the charms of fitness and honest simplicity have been given to it, and by accepting the comparative valuelessness of the metal, it has been used as the vehicle for slight thoughts and slighter execution. It should not be without result that by far the greatest of our designer sculptors, the late Alfred Stevens, worked long and thoroughly as a modeller for cast iron, from no choice of his own, it may be, nor choice, probably, of subject; and yet by far the most popular work of modern sculpture, the little lions on the outer rail of the British Museum, of which so many other artists are glad to keep casts by them as examples of breadth and style, are only cast iron. That they should be painted such a repellant colour is but an accident of their fate—the irony of fate. The torch holders on the top of the same screen, with reliefs of heads surrounding the bowls, are also his. Table supports, stoves, and grates also occupied his care. Some of them are described in Mr. Armstrong's book, and a specimen may be seen in Chelsea Town-hall.

At South Kensington, in the buildings on the west side of the road, there are two well-modelled dogs, modern French work, bronzed on the surface; and in the museum of the School of Mines, in Jermyn-street, there are several works, statues, and other dogs, after the antique, as well as modern work; one of these is especially interesting, for it is shown as it came from the mould, with seams, jets, and supports not cut away, nor any surface chasings. At a doorway at the west end of Conduit-street stand another pair of dogs in iron. Many of the firebacks which we shall notice later are low relief sculptures of considerable merit, especially that at Bruges, which has two nude figures some 3 ft. 6 in. high, as supporters to a shield.

The invention of casting in iron seems to have been made very early. Pausanius says of Theodorus of Samos—a sort of antique Cellini to whom they appear to have ascribed most wonderful works in metal, and who is supposed to have lived in the 6th century B.C.—that he cast figures of iron; and both this writer and Pliny mention other statues of this material. An Etruscan statue and a head of Roman work are said still to exist. England, we know, was extensively worked for iron by the Romans, and vast cinder beds have been found near Buxted, in Sussex, with scraps of pottery and coins of Nero, Vespasian, and Diocletian. Iron rings formed the currency of the natives when Cæsar "came, and saw, and conquered."

There is, however, I believe, no evidence to show that casting iron was practised here before the Middle Ages, nor at what time it was then introduced. M. Viollet-le-Duc, who more than anyone knew the history of Mediæval crafts in France, does not mind supposing that it was known there in the 13th century, to which date he attributes a fragment at St. Denis. In the 14th century cast-iron artillery was probably founded all over Western Europe, and it is likely enough that this may have introduced the furnaces into Sussex, in spite of the couplet which says—

> "Master Huggett and his man John
> They did cast the first Cannon."

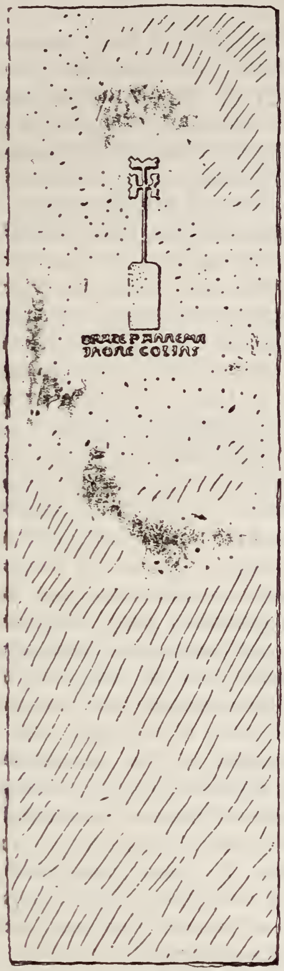
Magnificent bronze sculptures we know were cast here in the 13th century by Torelli, the artist of the lovely Queen Eleanor's tomb at Westminster Abbey.

If so introduced with artillery, the founders soon cast other objects. There are in the churches of the counties of Sussex and Kent a large number of grave slabs, the earliest of those known being at Burwash; this is shown in the figure above. From the form of the cross and the Lombardic lettering it is almost certainly a work of the 14th century. Mr. Lower, the writer of an able paper, from the historical side, in the second volume of the Sussex Transactions, gives this date; he says the inscription is a good deal injured, but reads—

ORATE. P. ANNEMA
JHONE COLINS

The placing of this on the plain field of the slab is full of art, and characteristic of early taste.

Fig. 1.



Iron Grave Slab at Burwash.

At Crowhurst is a sepulchral slab inscribed to Anne Forster: it bears figures—an effigy of herself, and on one side two boys, on the other two girls kneeling, below are small shields of arms, a lion rampant, and a cheveron with three greyhounds—it is surrounded by borders of running grape-vine, certainly good Gothic work, and earlier than the date 1591, which the slab bears; these patterns were kept in the shop and frequently re-used. The inscription in nicely formed and spaced letters reads—

HER LIETH ANE FORST
R DAUGHTER AND
HEYR TO THOMAS
GAYNSFORD ESQUIER
DECEASED XVIII OF
IANUARI 1591 LEAVYING
BEHIND HER II SONES
AND V DAUGHTERS

not forgetting to turn a few letters upside down and other way about, which was most carefully seen to in old inscriptions, so that those who ran should not read. There appear to have been several repetitions made of parts of this slab for firebacks. Mr. Longden has one of these, of which a drawing from a rubbing, is on the wall. In the meanders of vine the pattern is formed by repeats of one small portion which was either impressed separately into the flat field of the sand mould, or several casts of it were attached to the foundation board. I also show a full sized sketch of this ornament, which may be compared with another tendril of vine also of 15th century work; Gothic, if late, of a very good style, re-used on a fireback of later date at Buxted.

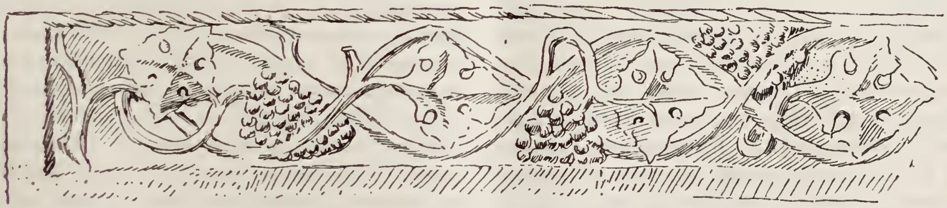


Fig. 2.—Design in Iron Fireback at Buxted.

There are a great number of these slabs; examples are at East Grinstead, 1570, and Witham, 1582; also several at Wadhurst, one with coat-of-arms, crest, and inscription dated 1648; another has six shields charged with three stars and initials "W. B.," and a late slab (1752) bears in brass letters on an iron plate the epitaph of "John Legas, gentleman, who, by his industry and intelligence in the iron works of this country, acquired a handsome fortune with great credit and reputation," &c., which is much more modern than the early Gothic sentiment, "Pray for the soul of Jhone Colins," who has also been identified with a family of ironfounders. In Frant, near Tunbridge, there are also several slabs with shields of arms. Later examples again may be found at Streat, and sometimes an iron plate of inscription is inserted in an outdoor tomb as at Alfriston, or a low cross, is entirely iron as at Croydon, and all of them have the charm of an endeavour, simple and unaffected, which, with a child-like directness, knew nothing of art but wrought it: talked nothing of beauty but thought it.

In the great open fireplaces where logs burnt on the hearth of hall and kitchen, cast iron slabs called firebacks were put against the wall behind the fire. They are found alike in France, in the Low Countries, and in England, and invariably charged with some device, arms, inscription, badge, or a scene Scriptural or classic, an allegory or a fable, something to suggest a thought, as the pattern adorned the opening in summer or burnt red hot behind the winter fire; all these things were books.

One of the largest and best in the modelling is that at Bruges before-mentioned, with figures of nude savages, gentle as Rousseau's natural man, supporting a shield. They are too high in relief, but evidently the work of a very good sculptor, and dated 1565. I have on the table a slight sketch of the Eve. The rest of the fireplace is entirely covered with cast-iron plate, diapered over with a pattern of quatrefoils and shields. Mr. Longden has two French figure panels, dated 1518, which probably formed the cheeks to such a metal-plated fireplace; and Mr. Blomfield in his interesting papers in the "Portfolio" for 1886, mentions firebacks that used to exist at Linham, Kent, "covered with men and great roses, and extending across the entire chimney back." The great roses remind us of the plaster work, painted in natural colours, of the inn kitchen in Mr. Morris's "Dream of John Ball," a suggestion of the sweeter things of nature is alike welcome in cast iron or in cast plaster.

The earliest of the south county backs I know of belongs to Mr. J. C. Horsley, R.A., at Cranbrook, and is certainly good Gothic work in flat tracery of a sort of butter print style, and the sacred monogram, X.P.C. There is a drawing of this example the full size on the wall.

In another place I have spoken of the necessity of the relief being flat, and modelled but slightly, not rigidly carved with sharp definition. This last example is, however, almost certainly from a carved original, and Mr. Blomfield mentions actual patterns of wood in existence; but the dull unobtrusive relief is not less successful for being carved. They knew what they were seeking for in the finished work, and found it, whereas our patterns are for the most part thought out as carved wood and cast, The back in the farmhouse at Buxted, which has the early vine pattern, is of Queen Elizabeth's time. The decoration is amusingly haphazard; first, the Gothic meander impressed along the top, and in the centre the crowned rose of the Queen, and the letters, "E. R.," all in matrix instead of relief, and the letters wrong side foremost; a plaster mould apparently, instead of an object, has been impressed into the sand. There are two other roses impressed in the same way, and two shields the right way up.

This casual look of old work is not so accidental as we may be likely to think, for in the carved work of the same time we find letters reversed, or top downwards. It is clear they looked on letters as designs, and cared little for the laws of Medes and Persians or those who dare neither play nor smile over their work. A dreary dead level of dull accuracy is nearly the chiefest incubus that paralyzes our present crafts, until art becomes but another weariness.

The ornament, whatever it may be, in true Gothic is always some suggestion of life and growth, roses or vine. This, not buttresses, cusps, nor tracery is the living principle of pre-Raphaelite art: and the reverse of this, not symmetry, nor simple mouldings, nor large forms, is the essential impurity of the corrupt Renaissance. Since Della Robbia modelled his wreaths of lemons, apples, and fir cones, hardly a single fresh thought, the sight and scent of flowers, or spring of living foliage, had inspired pattern decoration until Mr. Wm. Morris, whose work it would be difficult to speak of in measured words, so stimulating it is in adapting from nature the evergreen source of all new life in art. A colour pattern of his is not a mere re-shuffling of the beggarly elements of design, but an impression of how bright stars of jessamine twinkle on a twilight of green. As Mr. Blackmore's John Ridd says, "The more a man can fling his arms (so to say) round Nature's neck, the more he can upon her bosom like an infant lie and suck, the more that man shall earn the trust and love of all his fellow men."

The later firebacks are very numerous, although for the most part now in "collections" instead of adorning the cottage hearth or the hall for which they were specially made, for hardly any exact duplicates occur, and in very many instances the arms or an inscription identify the former owner's family. A back at Misfield, in Sussex, is a charming design; at the top in a little gable the crowned badge and supporters of Elizabeth and five tiny shields, with an inscription—

THOMAS UNSTED ISFIELD AND
DINAS HIS WIF: ANO DOMINI. 1582.

all mixed up, together in amusing confusion of wavering lines of letters. Or another—

THES IS FOR JAMES HIDE AND ION HIS WIF
1582.

The coats-of-arms are large or small, with or without supporters, or a number of small shields fill up the whole space; many have the Royal arms, others horsed warriors galloping in attitudes expressive of a consciousness of the converging gaze of nations.

The Scripture scenes are telling groups of Abraham and Isaac, David and Goliath, the Queen of Sheba astonished at the splendour of Solomon, the Annunciation, and the Woman of Samaria; or Michael casting Satan out.

Classic story has Venus and Adonis, Pallas, Juno and Venus, Hercules and the Lion, Neptune, Apollo, Vulcan in his Smithy, and Juno in a Car drawn by Peacocks, or there are Fables of Esop—The Thief and the Dog, or Fox and Crane. There are Seasons and the Four Quarters of the World, Allegories of Time, Peace, Fame in a Chariot and the necessary Trumpet, vases of flowers, trophies, a Parrot in a Ring, Chariot driving over a Bridge, or Early Bird getting the Worm.

There are many devices that refer to the Stuart Kings, Charles I. on a Horse, and letters "C. R." An anchor crowned, and the same initials; or an oak tree lettered "Royal Oak" and "C. R." again. Good examples of royal arms are at Hampton Court.

The most beautiful example known to me is one of which a photograph is kindly lent me by Mr. Longden. A Roman Soldier with a long spear, in three-quarter back view, within a margin line which sprouts out flowers and a flowery top and borders; it is a work of very considerable skill, sense of decorative spacing, and a touch unconscious and unaffected. The date, 1746, of this example would probably be later than the original model. Another of "Lord Fairfax" riding, fills the field well; the horse, the attitude, and the flying drapery remind one of the old broad seals on which the design is evidently founded. Another, of which I have a sketch,

Fig. 3.

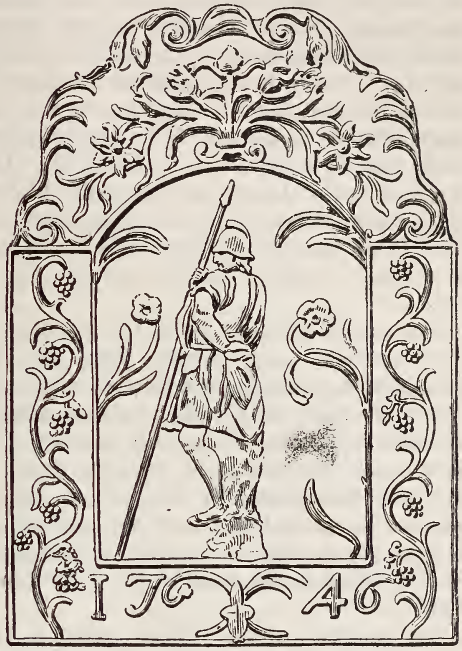
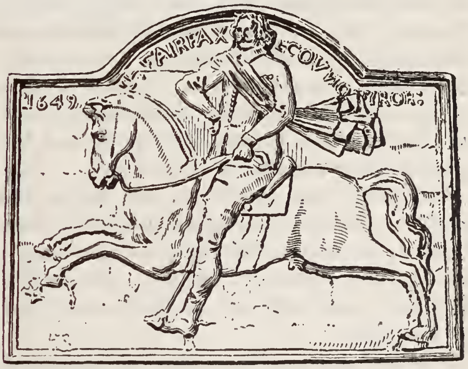


Fig. 4.



Iron Grate Backs.

has for centre a large apple-tree, with a Cavalier and a Lady on opposite sides, she offers him a flower—a new Eve.

A beautifully designed example, with many others, is in the possession of Mr. Elsley. Within a wattled sheepfold sits the genius of a country, on a staff she upholds the cap of liberty, and before her a crowned lion strikes a most ramping attitude with sword and thunderbolts ; it is lettered "PRO PATRIA." Others have a single figure of a girl with a bird on finger, or pouring wine, or a vase of flowers is made to fill the ground, with great skill in distribution of the forms. In the Museum at Lewes, a salamander basks in his native element with much complacency. The second figure of the date of this one, 1550, is certainly "forged" in both senses of the word.

The actual achievement in the poorest of these firebacks is low enough. Some are, in fact, almost grotesque, but yet they all have that fresh touch of a real motive, a direct reference to some expressive gesture or pleasant object ; all treated with great simplicity, and that instinct for balance and spontaneous fitness and freedom in the ornament, without any forcing the material or obtrusive display which is the mark of the traditional crafts.

The system is, almost without exception, to keep a flat field, which shows in pretty wide spaces all over, and the modelling on this is in low relief—the less the better—evenly balanced and of equal weight throughout, so that the light is distributed in narrow edge lines right over the surface. To sum up in a word, a decorated plate of iron, instead of a cast sculpture of bossy high lights, and the ground lost in the weight of the relief.

Accepting this treatment, the better the sculpture, indeed, the better, but yet it must suggest, not realise, the slightness and vagueness in parts fading to mystery. The best of all reliefs, as Mr. Ruskin so finely says, "are but shadows"

The firedogs or andirons which accompanied the backs on the hearth make a parallel series. De Caumont and Viollet-le-Duc cite examples of late 14th century and early 15th century in France ; and a sketch I made in the Museum at Angers, of a Gothic example of this date is on the wall ; many of later date still carry on the Gothic forms in England ; from an arched base, sometimes cusped, springs a stem, which carries a small shield, a capital, or a head ; several examples may be found figured in the articles before quoted. They are interesting historically, but are not, I think, the models we should follow. We have seen enough of the "Gothic revival" in cast iron ; what we want is new thought based on practical needs, and the Gothic spirit of a search for beauty untrammelled by formulas. Still later examples of the 17th century were figures or "terms," the best designed of which are signed "Carron." I bring here one of these of my own, a small female figure, and show a sketch of a terminal figure of a man which is both larger and better modelled ; but even the former, poor example enough as it is in its way, is much better than a far abler sculptor would be likely to give us who did not sympathetically approach the material he was working in, and design within rigid limits ; for, first of all, the figure must be just a solid post without weak projections or detail, and in this the old ones, without exception, are successful. Perfectly plain turned vase and baluster forms on a base, or obelisk-like posts on pedestals, were also used, and are probably as appropriate as any. Simplicity alone never fails ; it is the charity of design that will cover a multitude of sins. To aspire is well, but to aspire vulgarly and fail weakly is to make art an offence and distaste.

Other objects of the Middle Ages were vessels. Some years ago I drew one of a pair of large metal holy-water basins, like inverted bells, at St. Pierre-Sous-Vézelay, in Burgundy. I find that Viollet-le-Duc gives them as cast iron. "Two of these mortars of iron," he says, "have served a long time as benetiers in the Church of St. Pierre-Sous-Vézelay ; perhaps they are there yet ; they were of great size, nearly 3ft. in diameter, and very well cast, with ornaments and ring handles ; they probably came from the Abbey of Vézelay." He also illustrates another example with lions' heads carrying the rings.

The foundries of Staffordshire also produced small objects of this sort before the time of Elizabeth. "Brewing cisterns, pots, and mortars" are mentioned.

In Sussex the iron trade assumed such large proportions, especially after the introduction of blast furnaces worked by water wheels in Queen Elizabeth's reign, that the exhaustion of the timber in the supply of charcoal fuel caused much anxiety, and an effort was made to limit the industry. In 1607, an amusing tract argues the question in dialogue, the upholders of the local trade doing so on purely philanthrophic grounds. The clearance of the woods was a benefit to mankind, for "people bred amongst woods are naturally more stubborne and uncivil than in the champion (*sic*) countries." At this time there is stated to have been as many as 140 furnaces in Sussex.

I am not one of those who wish to see in iron a material for a new architecture, as it is called, nor do I wish its extended use, rather inversely a smaller field, but that field as full of flowers as may be. Mr. Ruskin, with that insight which makes him refuse to talk about the fringe of a subject, saw clearly when everybody was clapping their hands over the Crystal Palace, that the finding and founding of iron is not one of the radically nobler employments, as stone hewing and setting is, or the felling and framing of timber. I would echo every word he says. But while we use iron in some degree, while we even need iron, while even it may grow into wider necessary use, I want to say let us lend what grace we may to it, so that if obtained with cost, the greatest of all cost, an unkindly labour, it may not be mispent and more than spoilt, used to insult a trained understanding in the brutality of its vulgar insolence. For in all these things it is human life we spend; there is really no other currency, and so comes the reverence any true worker always feels for material.

Cast iron was largely used in the pleasant and refined manner of building, from the end of the 18th century, the typical London house. In the great area from Paddington to Pimlico, and Bloomsbury to Bayswater, there are an infinite number of examples of a quiet and charming taste. Railings, balconies, verandahs, with graceful posts and panels of delicate lattice; or inside the house, the grates and stair balustrades were just as good.

The railings begin with the very fine design of the enclosure to St. Paul's; great baluster-shaped forms of beautiful profile; the railings at St. Martin's-in-the-Fields following the same model; and there is a late example in Bloomsbury-square, where large rounded posts of this kind are used occasionally between straight uprights. Others have wide pilaster-posts at intervals, like a beautiful railing close to Apsley-house in Piccadilly; or others have solid discs placed in the lozenges of lattice work, as on the west side of Lincoln's-inn. Even the ordinary area railing of straight bars has cast knobs and vase-like forms on the top, entirely good in their way, and everything so compact that you never see parts fractured.

The balcony railings are very light—a network of lattice. For perfect fitness, a natural and unashamed treatment of casting in iron, they could not be bettered. We never think of comparing them with wrought iron to their disadvantage; both are excellent in different categories, and we might as well compare London-bridge to Lady-day; whereas, modern castings do invite comparison with wrought iron, by an infinitely careful ingenuity of pattern-making, emulating just those qualities in which to succeed is only the most of all to fail. For not the line, as in wrought work, the bent rod in scrolls, but the plate, plain or pierced, is the primary fact, a panel of equally distributed substance, or it will fracture in cooling. To get the most out of these natural aptitudes—that is art, by the simplest means—that is perfect art. In a word, the ratio of visible effort and economy of apparatus to the ends achieved, is the measure of our enjoyment of a work.

The verandahs, many of them, are equally excellent, also some of the older lamp-posts. For the stair-railings, the usual plan is to have a wide, flat baluster of open work, one to each step, the metal very thin towards the view, and perhaps beaded. I remember to have seen a wide stone stair of the town-hall at Cherbourg; there was a continuous balustrade of cast plates of iron, pierced with apertures into forms, each edged all round with a delicate raised fillet; it was certainly successful. The French use cast iron largely, and much of it designed with better taste than our own, and much, I believe, with worse. Where it is the work of one of their abler architects, as in the St. Geneviève Library, or the Northern Station, or the Palais de Justice, it is carefully studied and refined. Doors are also made of it, especially for tombs, and these are suitable, which cannot be said of the elaborate pair of Berlin castings at South Kensington, which may be taken to exemplify the "thou shalt not" of cast iron. A sheet of old designs I have also shows arcaded trellises for gardens, of equally reserved taste.

In Italy also, cast iron has been used for balconies, grilles, and that sort of thing; the turned baluster is a favourite form.

The grates that fill the older houses in London are, for the most part, of excellent design, and remarkable examples of careful casting; some are quite plain, with just a moulding or two, and others are fluted and beaded all over with tiny ornament on flat surfaces; the simplicity of the general forms saves the ornament from being worrying. A very beautiful grate of this sort was designed some years since by Mr. Philip Webb. There are also a great number and variety of knockers.

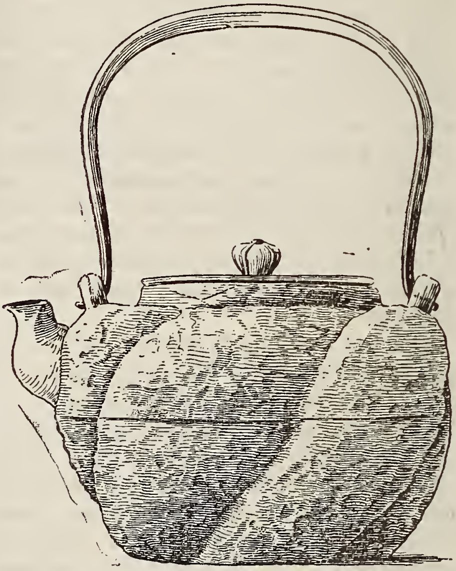
It is interesting to find in the East a school of casting in metals, poles asunder to our own, especially in its appreciation of the iron; there without doubt the abstract and absolute quality of the metal is admired, apart from the mere accident of its comparative cheapness. Japan is particularly famous for its iron workings, but casting is also well known in China. Some years ago, a chain of cast iron, of antique Chinese make, was shown at a meeting of the Archæological Association. Bells and many other objects were also known. But the most wonderful works of iron are the sculptured *tsubi* or sword hilts of Japan now treasured in the cabinets of collectors all over Europe, as well as in Japan itself, each one of tens of thousands a marvel of design and skilful handicraft. Iron has been also largely used as a basis for incrusting other coloured metals upon in raised designs, but those works that especially belong to us this evening are the cast iron tea kettles and vases, of which great numbers have been brought to England, every one a truly individual work of art, fresh in design, and a wonderful example alike of casting, of decorative sense, surface texture and colour. Mr. Phené Spiers has been kind enough to lend me two or three examples. A vase is not so large as some, but an interesting article of workmanship. The kettles are most charming, one with a slightly sketched band or fret ornament, and a surface that artfully reproduces the accidental handling of the wax original. The colour, a fine reddish grey, is entirely beyond my knowledge to suggest how it is obtained. The smaller and, I suppose, much earlier example is even more fascinating; about the size and shape of a small glue-pot, with slightly sunk discs, containing inscriptions in soft floating relief, and the surface clean untouched iron, with all the rough texture of the granular particles.

There are a few examples at South Kensington, a small beast and two kettles. These are damascened in silver, and the lids are of precious enamel, which sufficiently shows that the artist delighted in his iron as a material of special and singular beauty.

Dr. Dresser's book tells us these kettles were modelled in wax on a core, and the model was destroyed in the first casting, so that repetition was impossible without remodelling, and who would remodel without variation? The model finished, a thin batter of very fine clay-like sand was mixed with water and spread over the model; a second and other coats of a coarser material followed, and then hard sand was pressed solidly around the whole. When dry, it was put in a muffle and the wax evaporated, the metal afterwards occupying its place, as in the well-known *cire perdue* method, by which the best works of bronze are cast.

The first mentioned example of Mr. Spiers' and a kettle here of my own, which is signed by the same Japanese craftsman, are, however, certainly cast in piece mould, the first in three sections, and the second in two pieces. It is of singular beauty in the melon form of the body, with the wrinkled and pitted surface of the fruit given in the modelling, the resulting texture partly shining where rubbed and dull in the hollows. The seam of the mould shows without any disguise right round the body, certainly an added beauty and interest.

Fig. 5.



Japanese Kettle.

When cared for thus, and not degraded by mere commercial production, which values the iron only—as Sir John Maundeville said, the people of India worshipped the ox "for his meekness and for the profit that comes of him" —when cared for, the metal has a distinct place; it is our treatment only that is ignoble.

Again, let me say, the position I want to make clear as the point of view of these notes, is not at all a claim to widen the application of iron, or that it is in any degree superior to other materials. Each material is the best, and our use of iron castings is sufficient, indeed excessive in all probability; but the claim is that if we elect so to use iron, we can do so for the direct "spiritual," if I may so use the word, appeal of the metal to the imagination; or, secondly, if for humbler and utilitarian reasons, it must be good in work and in thought —a work of art. Even the purposes which the worst and most offensive examples have served might, for the greater part, actually have been filled by cast iron if the work had been naturally done; thought of first as use, then as beauty, and never as an imitation, but honest, simple, and delighting in itself—the property, that is, of being cast. Let us think of even the most irritating of these, the cast-iron foliage on doors, always fragile, feeble, and false; but if we begin by appreciating the modelling as the essential factor, we may stud the door over with bosses or discs, put cross ledges of thick iron with modelled devices, cover the doors with plate, or fret it with ribs bolted on.

If the uses are not few, the methods of treatment are many. We must, however, accept the necessary limitations that sculpture or ornament must be modelled, not carved, wherever it is proposed that the finished result should be a casting either in metal or other materials. The base may be wood and the ornament modelled in applied wax, which Viollet-le-Duc has stated to be the old method. The ornament, whatever it is, must be a surface decoration of a general simple structural form.

Repetition is of the very nature of cast work, and hence the same form as we have seen was often many times impressed in the same mould Repetition of a few simple elements in different combinations made great actual variety possible, as in the firebacks.

As to surface, rust is without any doubt the natural treatment, and I believe we might well let nature have it so on occasion. Let us suppose a relief good in design, slight in finish, of the best iron, and absolutely untouched from the mould; put up under some simple pent, it will gradually acquire colour and texture—too much of both, you think, but I am not sure. Remember, first of all, how frightened we are of beauty; and that natural colour, and naturally acquired texture are the very adornments to beauty herself. A joke in Japan tells how the new servant-maid from the country polished off Time's lovely tarnish from a silver vessel, "to make it look bright and new." The joke would appear pointless to us, even applied to the tombs of Westminster. Decay is really much less than we suppose, especially on large rounded surfaces, and with even a small but constant amount of friction the metal keeps free of rust, or probably acquires a weather skin. Posts that block up roadways (of which there are a good many in Bloomsbury!), or the parapet of Westminster-bridge are examples; internal work, like the finely designed gratings in Kensington Museum, becomes quite polished.

Galvanising, the modern version of the tinning which, applied to iron, is as old as Theophilus, is a valuable process. Galvanising and good oil gilding right over the surface would probably be a perfect protection, or the galvanising might be lacquered and varnished in one or many lustrous tints, or in black and gold patterns, like the iron beams of large scales, one of the few simple decorations still done traditionally.

The black of Barff's process is also a valuable method; the Japanese set much store on a black oxide.

Electro-bronzing is another available method of which the French make use, and the dogs at Kensington are examples. Pliny tells us a statue at Rhodes was made of iron and copper for the sake of the colour. We find it possible to get Japanese workmen here to furnish out a shilling show. Would it not be possible to get one or two to instruct us in their processes in iron working, and especially in finishing and colouring the surfaces.

For some work oiling or varnishing may be sufficient, or thin Berlin black; in many cases, of course, painting is really necessary, for which I would recommend white, grey, or black as constant colours, although the real red of the post-boxes is not an example to be followed. Simple blackleading, too, is to be entirely approved.

Some old grates are inlaid in brass, which forms flush patterns on the surface. Lead might also be suggested, say for patterns and inscriptions on flat slabs, and might be merely beaten into the hollows left in the casting; or even cements and mastics might be so inlaid, if only properly designed. Turning might be used to finish the forms of balusters of severe classic patterns.

In conclusion, this business of iron founding is such a vast and important industry for England, that anyone might be proud to be engaged in it. A sense of beauty, and a reputation for skill are also (but it is a degradation to put it in this form) very marketable commodities. How would it be, do you think, even in this severely "practical" present, while not neglecting necessary commercial conditions, to foster within that a school of art in ironfounding, in which sons of the house, gentlemen in education, should yet be proud to work as artisans. I entirely believe that manufacture in almost any of its branches (to take Napoleon's phrase) would be "a career open to talents," especially now as we have heard "the professions are played out." With due training and capability, a reputation, and some degree of success, is almost certain to be obtained in a craft considered and practised as an art. But even those who make art serve them in some degree, do it by trying to satisfy this or that taste in this or that style; they do not, as they should, establish a school of production, with Cellini the founder, Maestro Giorgio the potter, or our own Chippendale the cabinet-maker.

If our prosperity depends on international commerce, beauty is at once the most attractive and the cheapest of all inducements, and with honesty in the wares the only lasting one. Would it not conserve energy and subserve dignity if advertising were not the only art practised in so many manufactories? If the wares are good the buyer should be the seeker. All these things are so curiously and closely interwoven, that bad art goes with bad commerce, bad goods, bad society. Belgian cinder girders and riots of Charleroi. It is true in every department of work, of all materials, and of every form of pay, what the Ironmaster said to Emerson:—"There's always good iron to be had: if there's cinder in the iron, 'tis because there was cinder in the pay."

DISCUSSION.

The Chairman said the very interesting sketch of what had been done in cast iron would make this paper very useful as a record of past days. There could be no doubt that the two stumbling-blocks in the way of good productions in cast iron were, first, the endeavour to produce something more elaborate and fine than the material would admit; and secondly, the continual repetition of what was supposed to be art in order to sell it cheap. Mr. Lethaby had touched on the first point several times, and pointed out what kind of things should be modelled in iron. The pattern should be simple, it should not be too highly finished, or be in too high relief, but it must be such a thing as comparatively coarse granular material could show without feeling that the material had fallen short of what was expected of it. He had made a note of interrogation against what had been said of Della Robbia, for he thought one of the things to be most avoided in the treatment of cast iron was anything like the direct imitation of nature, because in that, of all materials almost, you found the coarseness of the material stood in the way of anything like a proper reproduction. He thought Della Robbia's modelled flowers and fruit painted as nearly like nature as he could get them were utterly wrong. He admired his sculpture, of course, but he could not stand his painted fruit and flowers, and he thought the comparison of William Morris to Della Robbia did the former great injustice. None of Mr. Morris's designs from fruit and flowers were literally copied from nature; they were always conventionalised with a view to artistic treatment, while Della Robbia's were not. On the question of repitition, and the use of cast-iron ornaments in relief for such objects as fire-backs, that was admirable, because you wanted a thick plate of iron there to stand the heat, and *repoussé* wrought iron would probably not do so. So long as you did not go on multiplying a fire-back, and sell it by the gross in order to do it cheap, and so long as you made it when wanted, producing a design which would stand the heat, it was perfectly legitimate art. It was not legitimate when people began to make what they called highly decorated pieces of wrought iron, canopies and balconies of a very ornamental kind, and then reproduced them, and boasted that they could let you have these beautiful ornaments at such a low price as compared with wrought iron. It was a dangerous thing, however, to speak one's mind too freely on these matters, as he had discovered. Some time ago he made some strong remarks about the cast-iron productions of a very large firm, well-known in the North, which went in for ornamental cast-iron mantelpieces, and centre-pieces with spreading branches, and so on, and he got a letter from the firm telling him that next time his advertising agent came to them for an advertisement he would find out his mistake. With regard to the use of cast iron in structures, he came across a very remarkable instance of what he called the false use of cast-iron ornament in the roof of Olympia, which he went over with the engineer, who was very proud of his work, before it was quite finished. It was a splendid piece of work, and he was much struck with the way in which he had supported the great roof principals on fish-shaped cast-iron pieces, thicker in the middle and pointed at the top and bottom, where it was in a socket, so that on expansion or contraction it quietly turned as far as was necessary. It looked very elegant, and thoroughly answered its purpose. He remarked to the engineer that that was a new use of iron, when the latter replied that it was not yet finished; there was a Corinthian capital to go round the top. The Corinthian capital had nothing to do with the design or the construction; but it was to be put on because people were in the habit of seeing a capital on the top of a column; and, as the engineer said, they would expect it, and he dared not leave it out. That was a flagrant instance of the way hownot to use cast iron, and the man who did that spoiled the best merit of his own design by trying to do something with it which was not fitted to the material. He was much interested in the statement from Dr. Dresser that the Japanese used the *cire perdue* process in cast iron, which would, of course, enable finer-surfaced work to be done, and a higher finish in relief-work to be obtained than by casting in sand. He did not quite see his way to adopting the idea of leaving the iron to rust, although it did produce a fine colour; he feared the tendency would be to rust too much, and to destroy even the bold design which Mr. Lethaby rightly recommended. He agreed with him that anything was better than paint, though that had to be used in large engineering works, being the only real preservative; but in smaller works he should much prefer some of the other processes which had been mentioned.

Mr. HUGH STANNUS, both personally and as a member of the Company of Founders, desired to tender his thanks to Mr. Lethaby for the very interesting and exhaustive manner in which he had treated this subject. He had shown in the historical part of the paper that cast iron had a dignity and nobility, when properly treated, which too many in the 19th century were apt to ignore. The danger in working cast iron had always been in making it imitate other materials. As he had said on a former occasion, the attempt had been to make it imitate in the first place the forms of wrought iron, and, secondly, the forms of stone, to neither of which it was suited, and the result was vulgarity. Reference had been made to Stevens and his wonderful little sitting lion; the lion was modelled by Stevens, but it was scarcely his design. It was modelled from a sketch which the late Sidney Smirke made of the pretty little lion on the staircase in the Bargello palace at Firenze; but Mr. Stevens had put so much of his own feeling into it that it might almost be called a new creation. It was the finest sejant lion ever made. Stevens, in his treatment of iron, might be said almost to be the Mozart of iron. Music had been be divided into the pre-Mozart and post-Mozart periods as art was divided into pre-Raphaelite and post-Raphaelite; and so with cast iron, there was a pre-Stevens and a post-Stevens period. The new inventions and new treatment which Stevens introduced when he went down to an iron and bronze foundry at Sheffield would require an entire lecture to deal with. Some interesting examples had been given of grave slabs, but no reference had been made to that wonderful set at Nuremberg. They were great iron workers there, and many of the grave slabs were of cast iron, and very dignified they looked. Fire-backs were a very legitimate and very interesting use of the material, and in his rambles about the country he often admired in the cottages those grand old Sussex fire-backs. The way in which they showed what Mr. Lethaby called "mystery" was very interesting; and he was reminded of a similar instance in Stevens's work, a cast of which he had lent to the present Stevens' Exhibition at the Royal Academy. It was the back of a stove; the front bars were straight, but the back of the stove was semi-circular, and the upper part of that back contained a low relief of the carrying away of Persephone, which belonged to the Plutonic cycle of myths, and was exceedingly appropriate to such a position. There were the fiery red-hot coals and the smoke going up, and there was old Ploutos carrying away Persephone in his chariot down to "hell." Andirons had been spoken of, and there were several splendid examples still existing in Sussex. It was very important, as had been said, in cast-iron, to attend to the sectional area. If there were a thin part it would cool more quickly than the thicker part, and when the other parts cooled it would snap. It was very necessary, therefore, in these andirons to make them of similar sectional area, and that accounted for what appeared at first sight a little want of variety in their shape. It was an instance of the law of the survival of the fittest, and the mere fact that so many of these had survived, showed that they had been made in a form consonant with the nature of the material. Allusion had also been made to stove-fronts. In the Adam's period there were delightful little ornaments, either modelled in wax or cast in lead, and bradded on to the wood mould. Some years ago, at the Carron Company's office in Thames-street, the London partner of the firm showed him an old pattern-book, of contemporary date, full of beautiful designs in the Adam style. He entirely agreed as to the absurdity of cast-iron Corinthian capitals where leaves were fixed on to a central core; but it was interesting to note that, as the name implied, this was the way in which the capital was first designed. The Greeks in the Corinthian time, about the 3rd or 4th century B.C., were great workers in brass and bronze, and any article made of this material was called Corinthian brass. Gradually the word "brass" was dropped, and the word "Corinthian" retained; and so what had originally been a Corinthian brass capital became called a "Corinthian" capital, just as Birmingham *brass* candlesticks had come to be called "Birmingham" candlesticks, and Damascus cloth, "damask. This showed, therefore, that originally the leaves of the Corinthian capital were made separately, and applied to the marble core. There were existing some Roman ruins at Baalbec, and one of the temples showed what is called the bell of the capital, with holes round the bell in which the leaves were put on separately, the holes being for the rivets. On the question whether these should be added in external work, he agreed with the Chairman, because they knew that water got into the apertures, and either oxidised the iron, or, in time of frost, burst away the leaves. He would draw attention to some interesting capitals of the general Corinthian shape, designed by Mr. Godfrey Sykes, in one of the arcades at South Kensington, which were entirely cast iron in their treatment. With respect to rust: it was a good custom to let iron rust as far as it would, and then if it were a small object, to slightly heat it, dip it in oil, and brush it. The result was, it would never go any further; and it acquired a magnificent patina which was a true colour of iron. He thought there was one general law for the colour-treatment of all metals, that the colour should be either that of its crystallisation or oxidation. There was only the choice of those two, and he should like all metals to be confined to those two. It annoyed him very much to see iron painted white, green, or vermilion; of course, the post-pillars were painted red, like the postmen's livery, because of the royal scarlet, and because the red was conspicuous, like a druggist's lamp; but, except for some such reason, the colour of iron should be confined to that of the fracture—which was a silvery grey—or its oxides. He begged to move a hearty vote of thanks to Mr. Lethaby.

Mr. TARVER said one form in which cast iron was coming very much into vogue at the present day was in the form of mantelpieces. He did not care much for that himself, but it was marketable, and it occurred to him that there was one thing about the form which might be taken advantage of. If the mantelpieces were made with the return sides at right angles to the front, there was always a difficulty in making the cast deliver from the mould; but if makers would accept the conditions of cast iron, and splay the sides slightly, there would be no difficulty on that score, and there would be a possibility of putting some ornament on the return sides, which was often necessarily shirked with right-angled sides. Amongst many articles which had been mentioned, no reference had been made to oven doors, but he had had to do lately with a house in Grafton-street, where he found in the basement an oven of which the door was most beautifully decorated with female figures. It was octagon in shape, and was evidently intended for the oven, and it showed that the artists of those days did not neglect even so useful a thing as an oven. He had much pleasure in seconding the vote of thanks.

The vote of thanks having been passed,

Mr. LETHABY, in reply, said he did not mean to suggest that there should be a direct imitation of nature in cast-iron work. He should like it as direct as possible, but then came in the question of what "direct" meant. What he said was a sign of nature within the limits of the material. Mr. Stannus had been good enough to support him in what he said about rust; he did not suggest that it should be universally employed, but that it was one method, and nature's method.

TENTH ORDINARY MEETING.

Wednesday, February 12th, 1890; SIR DOUGLAS GALTON, K.C.B., D.C.L., F.R S., Vice-President of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Fawcett, Richard, Wirksworth, Derbyshire.
Gearns, John, 12, Finsbury-square, E.C.
Linnell, William, The Avenue, 76, Fulham-road, S.W., and Hillsbrow, Redhill, Surrey.
Moore, Alfred, Queen's-buildings, 2, Ridgefield, Manchester.

The following candidates were balloted for and duly elected members of the Society:—

Burnie, Alfred, 165, Fenchurch-street, E.C.
Dell, Holland, Cowley-villa, Sunnyhill, Streatham, S.W.
Griffin, Beverley, Mount Pleasant, Rickmansworth, Herts.
Newman, Philip Harry, 45, Broadhurst-gardens, South Hampstead, N.W.
Parry, Edward, 28, Park-row, Nottingham.
Redman, Joseph Fell, 165, Osborne-road, Forest-gate, E.
Tidy, Charles Meymott, M.B., 3, Mandeville-place, Manchester-square, W.

The paper read was—

ON MODERN IMPROVEMENTS OF FACILITIES IN RAILWAY TRAVELLING.

BY GEORGE FINDLAY, ASSOC.INST.C.E.*
General Manager, London and North-Western Railway.

In the autumn of last year, I had the honour to act as Reporter for the English railway companies at the International Railway Congress, which was held in Paris, and in discharge of that office, to read a paper relating to a certain group of questions arising in connection with the conduct of the railway passenger traffic in England. These questions had reference, mainly, to the relation of the classes one to another, their relative power of earning revenue, the fares charged, and the composition, the weight, number, and speed of trains. It was shortly afterwards suggested by your Secretary that I should read this paper at a meeting of your Society, which I was not at all unwilling to do, but, on reviewing the matter, it appeared to me that the paper I read in Paris, being addressed to an audience exclusively composed of experts, if I may call them so, in railway matters, and being, moreover, encumbered with a large amount of statistical matter only interesting to such an audience, would scarcely be quite suitable on the present occasion, and I have therefore judged it better to approach the subject from a somewhat different point of view, and, without going quite so much into statistics, to present to you such facts bearing upon the question as will be most likely to prove interesting to those who are good enough to give me their attention this evening.

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* In the absence of Mr. Findlay, from illness, the paper was read by Mr. G. P. Neele.

On coming to consider the subject upon which I have undertaken to address you, and which I have ventured to describe as "Modern Improvements of Facilities in Railway Travelling," one can hardly refrain from devoting some little contemplation, at the outset, to the beneficial revolution which has been brought about in the life of the country, during a comparatively recent period of time, by the invention of the locomotive steam-engine, with which the rugged genius of the great North-countryman, Stephenson, startled the world in the early part of this century, and in contemplating that revolution, there is nothing more striking than the extreme rapidity with which it has been accomplished, a rapidity, one would almost say, eminently characteristic of the nature of the agency itself. For if we consider any of the other great social movements of equal importance, we shall find that they were the slow and gradual growth not of a few years but of generations, and sometimes of centuries, and that they have not arrived at anything like their ultimate development until most of those who were entitled to the credit of their inception have long passed away from the scene of their labours, leaving others to take up their work and carry it on. In this case, however, the child has so quickly grown to almost the perfection of manhood, that many of those who were actually present at his birth are with us still and are able, within their own individual recollection, to compare the old state of things with the new. I should like you to fully realise this simple and striking fact, that the great system of railways which covers this country to-day is, after all, but a mere bantling, so to speak, of little more than half a century's growth, and that there must be many persons still living whose memories can carry them back to the time, prior to the era of railways, when Manchester and Cornwall, or London and Aberdeen, were, in effect, as widely separated as London and Rome, or Madrid, are to-day; when a journey from London to the far north of Scotland was as momentous an undertaking as it is now considered to cross the Atlantic between the old world and the new; when, in country places, thousands of people were born, lived their lives, and died, without any wider knowledge of the outer world than could be gathered from a visit to the nearest market town. To us, looking back upon those days, it seems as if the want of speedy locomotion must have laid a paralysing hand upon all the affairs of man, whether of pleasure or of commerce, and we almost seem to feel the impatience of their slow methods which we fancy our progenitors must have felt. But, doubtless, they knew nothing of this feeling, and were well content with such fruits of progress in civilisation as they had already realised, and with the limited facilities for trade and commerce which at that time they possessed, so that, on the principle that ignorance is bliss, and that a man cannot be said to miss what he never possessed, perhaps we need not waste too much pity on our predecessors who never knew the advantages of railways.

And now, in less than 60 years from the day when the first primitive locomotive drew the first rude train from Manchester to Liverpool, what have railways accomplished for our benefit and for the benefit of those who will come after us? If I were to attempt to answer that question in detail, and merely to enumerate the many boons for which we have to thank the invention of railways, I fear I should exhaust the limits of space accorded to this paper, but in these fortunate days we are apt to take so much as a matter of course that it is, perhaps, worth while to mention, very briefly, just a few of the advantages we enjoy as compared with an earlier generation.

I wonder whether—say in the year 1820—paterfamilias was much in the habit of taking his family to the seaside in the summer months? I should say probably not, for although the fashionable world drank the waters at Bath or Cheltenham, the idea of transporting a large family, with all its *impedimenta*, to the seaside would have offered a prospect of trouble, difficulty, and expense calculated to appal the stoutest heart But now it is easily within the resources even of the humble clerk or shopman, with a little saving and self-denial, to take his wife and children to the sea to spend their holidays, and the undertaking is one which involves but a moderate expense and no difficulties whatever. Emphatically, it is the railways that have made the seaside watering-places what they are.

In former times, when young people of either sex left their homes to push their fortunes in distant towns they were practically exiled, for their small means would rarely permit of their affording more than once a year or so to revisit the paternal roof, whereas now the young folks so situated are enabled to spend their holidays, however short, amidst the family circle, and are thus retained to a much greater extent within the sphere of the parents' influence.

Formerly, those employed in towns and cities were forced to dwell there, for the loss of time in going to and fro between their business and the suburbs would have been too great to be faced, to say nothing of the fact that the roads were at night not always of the safest. Now, a great city like London is, at night or on Sundays, like a deserted village, for comparatively few live in it with the exception of caretakers. The multitudes who make up its busy throng are able to make their homes in the pleasant suburbs, north, south, east, and west, or even fifteen or twenty miles in the country; and the trains run so frequently, and at such speed, that the clerk, who at five o'clock may be hard at work in Fleet-street, at six o'clock may be sitting at his tea in his pleasant little villa at Watford or Dulwich, or elsewhere. I leave you to judge how incalculable must be the effect of this change upon the mental and physical welfare of the commercial community connected with large centres of business and of their families.

Why is it that letter-writing as an art has died out? Broadly speaking, it is because places in all parts of the United Kingdom are now brought so closely together in point of time, that if we have more to say to anyone than will come within the compass of a telegram or a brief note, it will usually keep until we can spare a few hours to go and see them. Thus, too, the merchant has the great advantage of personally seeing the people he does business with, instead of having to trust to agents or to correspondence.

I have but named a few of the advantages we have derived from the introduction of railways, but, generally, it may be said, without undue enthusiasm or exaggeration, that this great invention has imported a stimulus and a vital energy into all the affairs of man, whether connected with business or pleasure; has multiplied in a manifold degree our capacities and opportunities of enjoyment; has vastly increased the volume of trade and manufactures in the country; and has in a thousand ways contributed more to the happiness and welfare of our race than any other discovery or invention that could be named. There are not wanting, indeed, certain philosophers of the pessimistic school who are wont to deplore the fact that, in these lightning days of steam and electricity, we live at express speed—that we live too fast, in fact, and crowd into a few years the emotions and experiences that might well serve for a lifetime.

There may be just a grain of truth in this; but, to my thinking, the life of the full and flowing river is preferable to that of the stagnant pool, and I have faith that in the course of time; and in obedience to a natural law, the race of mankind has gradually learnt to adapt itself to the novel conditions of its being, and is enabled to lead a richer and a fuller life without in any way shortening its duration.

Up to this point I have been rather led into contrasting the state of things which exists to-day with that which obtained at a period anterior to the introduction of railways, and the train of thought is one which might be pursued far; but here I am reminded that my more immediate object in addressing you is rather to impress upon you the fact that the railway system as we have it to-day is the child of evolution, like most other things, and has grown up to be what it is from very rude beginnings.

So much has been said and written about the Liverpool and Manchester Railway that most people are now aware that this was the first public passenger railway, and that it was opened for traffic in the summer of 1830. It was originally projected to carry goods only, and the conveyance of passengers was an afterthought; but the directors soon found the latter a most important branch of their business, and they set themselves to cultivate it accordingly, although their notions of cultivation would hardly fit in with the ideas of 1890, and a glance at some of the old prints of the period will serve to show us the kind of accommodation which was provided at the outset, and for some time afterwards, for the conveyance of passengers. There appear to have been two classes of trains which were run separately. The first-class trains consisted of small vehicles on four wheels, very much resembling the old road coaches, from which they were doubtless designed, and each of these vehicles bore a name, such as "The Wellington" or "The Victory" (reminiscences, these, of recent warlike times) in the same way as the coaches they had succeeded. The lower class of passengers, conveyed by what were termed "second-class trains," were accommodated in vehicles very much resembling a modern cattle truck, having no seats or partitions, but with a light awning overhead and sides about three feet high. In short, the prevailing idea seemed to be that the only thing required was by any means to transport the passenger from one place to another, without consideration of inconvenience or discomfort, it being probably thought that as he had been accustomed to travel outside the coaches without protection from the weather, nothing more was necessary when he travelled by the trains. It should have been remembered, however, that even the outside passenger by coach had a seat provided for him; and some idea of the conditions under which the luckless "second-class" passenger travelled at this time may be gathered from the fact that as we learn there were frequent cases of their overbalancing themselves and falling out of the trucks or carriages while the trains were in motion.

The travelling, too, would be far from smooth or agreeable, and must have been very different from the easy, gliding motion to which we are accustomed, for the imperfectly constructed permanent way, laid, not upon wooden sleepers, but upon rigid stone blocks, was continually getting out of order, while the speed of the trains at first was, under the most favourable circumstances, not more than 20 miles an hour, and only exceeded by about one-third the speed of the fastest coaches which had been running previously.

The Liverpool and Manchester directors, pioneers, as they were, of the new movement, had many discouragements and difficulties to overcome in establishing their enterprise in public favour, and they and their able first chairman, Mr. Charles Lawrence, are entitled to great credit for the energy and perseverance they displayed in meeting these difficulties one by one, and profiting by the lessons of failure. For a long time their great trouble was the supply of locomotive power. When the line was projected, the question of motive power was left an open one, and it was not without hesitation and misgiving that they at length committed themselves, in spite of ridicule and opposition, to the adoption of their great engineer's invention. For a long time, reading between the lines of their early reports, it is easy to see that the subject was one of great anxiety to them, and at one time they made an almost piteous appeal to the ingenuity of the country to come to their aid with suggestions and improvements. The truth is that, although Stephenson had got his idea, in which he never lost faith, it required a great deal of perfecting before really serviceable engines could be produced, and at one time a rumour was actually circulated, although it was promptly denied by the directors, that they had decided to give up the steam-engine and revert to the use of horses for drawing their trains. We hear of the tubes and fire-boxes rapidly wearing out and burning away, and Stephenson and his assistants were perpetually changing the material and altering and experimenting in every way, the directors being, in the meantime, astonished and somewhat dismayed at the heavy cost incurred for repairs. It was thought that a veritable triumph had been achieved when, in February, 1831, a new engine, called the "Samson," conveyed at rain weighing 150 tons, from Manchester to Liverpool, but she was assisted up the heavy incline from St. Helens Junction to Rainhill by three other engines, and the directors in their report of the occurrence gravely admit that this engine was of extraordinary size and capacity, and perhaps too powerful for ordinary use! One cannot help wondering what they would have thought of one of the coal engines now in use on the leading railways which draw with ease trains weighing from 500 to 600 tons.

As the engines became heavier and more powerful, a fresh trouble arose, for now the greater weight and wear and tear proved too much for the frail permanent way, and the rails at first laid down had to be as soon as possible removed and replaced by others weighing 60 lbs. to the lineal yard, the stone blocks having long since had to disappear and make way for wooden sleepers. It may be mentioned in this connection that the fine steel track in use all over the London and North-Western system to-day is composed of rails weighing 90 lbs. to the lineal yard, each 30 foot rail resting on ten sleepers, to which it is secured by twenty chairs each weighing 45 lbs.

Our indefatigable pioneers, having at last got workable engines, and a permanent way which would bear their weight, had still new troubles in store, for they were next confronted by a strike of their engine drivers, and their places having to be filled with inexperienced men, a plentiful crop of accidents resulted. Some of the strikers, it may be interesting to recall, having signed time agreements with the company, which they disregarded, were promptly brought before the magistrates and committed to Kirkdale Gaol.

However, the Liverpool and Manchester directors, being first in the field, had everything to learn, but they frankly admitted and profited by their failures and mistakes, and in time were rewarded by seeing their enterprise develop itself into something more like what we understand a railway to be at the present day. Meanwhile their success, comparative, as it was, had had its inevitable effect, and new railways were, in the next ten years, rapidly projected and constructed all over the country, and as the promoters of these new undertakings were able to profit by the experience of the first comers, and to begin, as it were, where they had left off, the standard of improvement was carried on, and each new railway was an advance, in some degree, upon the one which had last preceded it.

Amongst other results of this forward movement, the companies began to cater to some extent for the comfort and convenience of their patrons, and even with regard to the hitherto neglected third-class passenger (or rather second-class, for in those days there were only two classes) after one company, in daring innovation, had raised the open sides of their carriages so as to prevent the passengers from falling out, another company actually went the length of covering in the vehicles altogether and providing rude seats. Surely the passengers of that day must have thought they had nothing left to sigh for.

The speed of the trains was meanwhile gradually improving, although nothing like the standard of the present day had been reached, and passengers of the lower class were only conveyed by trains stopping at every station.

I have recently been favoured by Messrs. Blacklock and Co. with a copy of a very interesting little book, which is well worth perusal, as it presents a picture, so to speak, of the railway system of this country just 50 years ago. It is nothing less than a reprint of one of the earliest issues of "Bradshaw's Guide," published in October, 1839, and it is a tiny duodecimo volume of just twelve pages, the price of which was sixpence. If you will compare this in your imagination with the familiar "Bradshaw" of the present day, it will convey to your minds, more forcibly than any words of mine could do, what fifty years of progress have done for us in the extension of our railway system.

In those days there was a railway between London and Birmingham, and one between Liverpool and Manchester, besides which there was the Grand Junction from Birmingham to Warrington and Newton-bridge, joining the Liverpool and Manchester at the latter place. The North Union Railway from Newton, through Wigan, to Preston, had been constructed, as well as the lines from Manchester and Kenyon to Bolton, and from what is now called Widnes to St. Helens. From Manchester to Leeds passengers enjoyed the advantage of a railway as far as Littleborough, near Rochdale, but the remainder of the journey had to be performed by coach. The Midland Railway existed from Birmingham to Derby and Nottingham, and the Great Western Railway, which has now the longest mileage of any railway in the kingdom, at that time was open only from London to Twyford, a distance of 31 miles, although it had been authorised, and was in course of construction, onwards to Bath and Bristol, while the London and South-Western had been made as far as Basingstoke, and the Brighton line as far as Reigate. In the north, what is now the North-Eastern Railway existed from Newcastle to Carlisle, and from Leeds to York and Selby, and with the addition of a short branch from Sheffield to Rotherham, this was all. Scotland, Wales, Ireland, Devon and Cornwall, and the Eastern counties were a blank, and the mountains of Wales and the highlands of Scotland must have been almost as much a *terra incognita* to the average Englishman as in the days of Rhoderick Dhu and Cadwallader.

A few illustrations, taken at random from this record of the time-tables of the past, will afford some idea of the extent o the accommodation provided in those days on the railways which did exist, as compared with what the public enjoy to-day.

Between Liverpool and Manchester there were eleven trains each way per day, but five of these in each direction were restricted to first-class passengers. The time occupied is not stated—probably it could not be guaranteed —but it was something like an hour and a half. The London and North-Western Company are now running about twenty express trains a day in each direction, and the Lancashire and Yorkshire and Cheshire Lines Committee an even greater number by each of their lines, the journey being performed in about forty minutes.

Between Birmingham and Liverpool there were, at that time, seven trains in each direction, while now there are thirteen; and whereas in 1839 the journey, even by the first-class and mail trains, occupied four hours, and by the second-class trains five hours and a quarter, it is now performed in about two hours and a half or two hours and three-quarters. The fares were 21s. first-class, and 17s. second-class; but now the first-class traveller pays only 13s., the second-class 10s. and the third-class 7s. 6d., while other fares have been correspondingly reduced.

Between London and Birmingham, although there were in 1839 nine trains per day in each direction, three of these were restricted to first-class passengers, and even these latter were five hours and a-half performing a journey that is now accomplished in two hours and three-quarters, while the mixed trains—that is, those which carried second-class passengers—took six hours. At this period, it will be seen, the passengers who paid the higher fares gained not much in speed but a good deal in comfort. The first-class coaches held four or six passengers inside, according to the amount of fare paid. Thus the first-class single fare from London to Birmingham was 30s. if the passenger travelled in a carriage holding five other passengers, but if he liked to pay 2s. 6d. more, or 32s. 6d., he could travel in a carriage holding four passengers only, so that he got more space for the extra money. The second-class carriages were closed and protected from the weather at night, but by the day trains they were open at the sides, without divisions, linings, or cushions, although the fact is carefully noted in the time-tables that "each carriage carries a small roof lamp by day and night." The second-class fare was 20s. by day and 25s. by night, the third-class fare, which now corresponds to it, being 9s. 5d. only, while the first-class is 17s. 4d.

It is not necessary that I should trace, step by step, the gradual improvement that took place in the speed and comfort of railway travelling for some thirty years after the period which I have chosen for illustration. The improvement was continual, if rather slow, but it is during the last twenty years that the most rapid progress has been made, and down to about the year 1870 the only material change in the position of affairs was that the whole country had been gradually covered with a network of railways, so that it was already becoming difficult to point to any spot upon the map on which a new railway was required.

Prior to the year 1872, the general practice of English railway companies had been to convey by the mail and the principal fast passenger trains only first and second-class passengers, third-class passengers travelling by less important trains calling at a greater number of stations, or by the Parliamentary trains, so called, which stopped at every station and which the companies were bound by statute to run over their lines at least once a day in each direction. For example, in 1872 the Parliamentary train from Euston to Liverpool, a distance of 201¾ miles, started at 7.40 a.m., stopped at every station on the route, and reached its destination at 6.35 p.m., thus occupying nearly eleven hours on a journey which the more fortunate third-class passenger of to-day is enabled to perform in 4½ hours. The fares charged at that period averaged 2d. per mile for a first-class passenger, 1½d. per mile for second-class, and 1d. per mile for third-class by Parliamentary trains, while fares at a little over 1d. per mile were charged for third-class passengers conveyed by a few fast trains of a secondary character to which third-class carriages were attached. At this time the third-class carriages were not upholstered in any way, and still contained nothing more than plain wooden seats, but were, of course, covered in as a protection from the weather.

The second-class compartments were fitted up very much in the same way as the third-class are to-day, while the first-class were very much like the second-class of to-day, with the addition of arm-rests. Foot-warmers were at this time supplied in the winter months only to first-class passengers, and to a limited extent to the second-class.

In the year 1872, the Midland Company adopted the practice (immediately, and of necessity, followed by all the other leading railway companies) of conveying third-class passengers by all their trains, while three years later, on the 1st January, 1875, they introduced the further innovation of abolishing second-class and running only two classes, which they termed, rather paradoxically, first and third, at the same time reducing the first-class fares to about 1½d. per mile. The other companies did not, at the time, follow the Midland Company's policy of abolishing second-class, although one or two of them have since done so to a partial extent, but all were at once compelled to place themselves on an equality with the Midland Company as regarded the re-adjustment of their fares, and this was effected by reducing the first-class to 1½d. per mile, making the second-class 1¼d. and the third-class 1d.

As regards the classes, most of the companies hold the opinion that society in Great Britain, and probably in most civilised countries, except, perhaps, in the United States, where there is a greater striving after equality, resolves itself naturally into three classes, and that the comfort and convenience of the travelling public are most effectually promoted by the general practice of having three classes of accommodation.

As this view has been challenged by a recent critic of mine, who was good enough to say that "of course, society does nothing of the kind, but the railway companies do it for their own profit and convenience," perhaps I may be allowed to endeavour to justify the statement. Amongst railway passengers we have, first, the nobility and the wealthy upper classes who will travel as luxuriously as they possibly can, without regard to cost; at the other end of the line we have the working classes, and the lower middle class, who must of necessity travel as cheaply as they can, while between these two extremes there is the great body of the upper middle class who cannot well afford the highest class fare, but can yet afford to pay something extra, and will make an effort to do so, rather than rub elbows with the honest wearers of corduroy. I think these natural divisions of society fully justify my view, and the existence of the three classes of carriage.

The effect of the new departures of 1872 and 1875 upon the earnings of the principal railways from passenger traffic was very striking indeed, and it must be admitted, and may be broadly stated at the outset, that of the many improvements in the facilities for railway travelling of which the public have had the benefit within the last twenty years, there is not one which has not been gained entirely and directly at the expense of the railway shareholder, and which does not represent a greater or less diminution of the profit which Parliament has authorised him to reap from his investments. I am not at all sure that the public fully realise this fact, or give the companies sufficient credit for it; and, indeed, it can hardly be denied that in these modern times the demands made upon railway companies on behalf of the public, not only for reduction of fares but for increased speed, more frequent trains, and superior accommodation have increased, and continue to increase, in such ratio as to render it exceedingly difficult for the companies to keep pace with them, while still preserving any reasonable margin of profit for their shareholders. There is, in fact, too great a tendency to look upon them as monopolists—a reproach to which, in these days of unrestricted competition, but few of them are open—and to bring to bear upon them every sort of influence, whether social or legislative, to exact from them new concessions without any regard to their profit or loss in carrying on the business. The public benefit, indeed, but the railway shareholder finds himself at times occupying the somewhat unprofitable position of a philanthropist, whose capital is invested for the advantage of the community at large.

It cannot be doubted that if it had not been for the fall, during recent years, in the value of materials and more especially of coal, and some other favourable circumstances, "the bitter cry of the railway shareholder" would have been heard in the land ere this, and if there should be, at any time, a material rise in prices, or loss upon the working of the goods traffic by reason of bad times, or if there should be any considerable reduction of the Parliamentary powers of the companies, which are now undergoing revision at the hands of the Board of Trade, the outlook for those whose capital is invested in railways may be a somewhat serious one.

I need hardly apologise for this digression, as it relates to a subject which is of great importance to the railway interest, with which every class of the community is more or less directly or indirectly concerned.

The immediate result of the adoption of the practice of conveying third-class passengers by all trains, coupled with the reduction of fares, was to largely increase the third-class traffic and the receipts therefrom, but to greatly diminish the receipts from the first and second-classes. On the London and North-Western Railway (from which, I must confess, my illustrations are mainly drawn) in the year 1871, the gross earnings from first-class passenger traffic were £728,779, or 13·59d. per passenger train-mile (*i.e.*, each mile run by passenger trains); but in 1888, the earnings from that class were only £480,780, or 5·81d. per train-mile. From second-class traffic in 1871, we earned £867,099, or 16·17d. per train-mile; but in 1888, only £328,771, or 3·97d. per train-mile. On the other hand, while in 1871 the receipts from third-class were only £999,051, or 18·46d. per train-mile, in 1888 they had grown to £2,433,485, or 29·38d. per train-mile. The net result of this wholesale transfer of passengers from the superior classes to the third-class was that the total passenger receipts per train-mile from all three classes combined fell from 48·22d., in 1871, to 39·16d., in 1888, this diminution representing, of course, a very serious loss of revenue when applied to a train-mileage of upwards of 20,000,000 of miles per annum.

During the past twenty years there has been a very marked increase in the speed of trains in this country, and more particularly in that of the express trains, which are now open to all classes of travellers. For example, in 1872, the fastest trains between London and Liverpool, a distance of 201¾ miles, performed the journey in 5¼ to 6 hours, while now it is accomplished in 4½ hours. Between London and Manchester, 188¾ miles, the shortest time occupied was 5 hours, while now the distance is covered in 4¼ hours. Between London and Birmingham, 113 miles, one train ran in 3¼ hours, but the others were much longer on the road, while to-day all the fast trains perform the journey in 2¾ hours. But the most remarkable development in the rates of speed is found in the running of the express trains between London and Scotland; and as regards these, it will be a sufficiently striking illustration to mention that the 10 a.m. Scotch Express from London, which in 1872 reached Edinburgh at 9.10 p.m. and Glasgow at 9.30 p.m., now starts from London at the same hour, but is timed to reach Edinburgh at 6.30, and Glasgow at 6.45. The journey to Edinburgh is thus performed in 8½ hours, and to Glasgow in 8¾ hours, but even this rate is sometimes exceeded, for during the tourist season of 1888 the journey to Edinburgh was accomplished in less than 8 hours, the distance being 401 miles, giving a speed throughout of 50 miles an hour, including all stoppages.

Messrs. E. Foxwell and T. C. Farrer have recently published a valuable work entitled "Express Trains, English and Foreign," to which I am indebted for some very interesting figures with regard to the comparison of the speed of express trains on the principal railways in this country and abroad. The facts they adduce are very striking, and should go far to convince English readers that they have every reason to be proud of their railways, and, whether with regard to speed or other considerations, they have little cause for envy in contemplating those of their continental neighbours.

As regards English railways, it appears that so far as speed is concerned, the Great Northern Company, doubtless owing to the straight course and easy gradients of a great portion of their railway, are entitled to the pride of place, for, notwithstanding their small mileage, as compared with their more powerful neighbours, they can boast of no less than 77 express trains daily running at an average speed of nearly 44 miles an hour throughout, inclusive of all stoppages; while the Midland Company have a large number of express trains running at a speed, according to time-table, only a trifle less than that of the Great Northern expresses. To save repetition, I may say that all the rates of speed I am about to refer to include stoppages—that is to say, that they represent the time occupied by the trains from departure to arrival, and the actual running speed would of course be considerably higher, and would vary on different portions of the route.

The London and North-Western Company have not hitherto made it their primary object to run their trains at the highest attainable rate of speed. In these days, journeys must be accomplished quickly, in order to keep pace with the times, and to meet the growing requirements of the travelling public, but the highest speed is not always the most compatible with safety and punctuality, and these latter essentials are certainly not the least important to be secured in the working of a great passenger traffic. In speaking of this question of punctuality, however, it must be borne in mind that, even on the most efficiently managed railway, there must always be a per-centage of late arrivals, especially at certain periods of the year, from causes which are quite unavoidable, and the utmost foresight and good management can do no more than reduce this per-centage to a minimum. For instance, in the summer months the passenger traffic is abnormally increased by the influx of tourists proceeding to seaside and other holiday resorts, taking with them enormous quantities of luggage, which add to the weight of the trains, and to the difficulty of getting them promptly away from the stations. Again, in the winter months, the trains are frequently delayed by adverse weather, to say nothing of the greatest enemy of railway companies, the fogs, which often descend over the whole country in an hour, and blot out the entire system of visible signals, so that the speed of the trains must, of necessity, be reduced, and more or less delay is inevitable, in the interests of safety, which is of course an even greater consideration than punctuality.

While upon the subject of punctuality, I may perhaps be excused for digressing for a moment to refer to a noticeable piece of good work in this direction recently accomplished by the companies who unite in forming what is known as the west coast route between Aberdeen and London. By an arrangement between the companies, the Christmas cattle from Scotland to the metropolis is carried in alternate years by the east and west coast routes; and this year, it being the turn of the west coast route, the bulk of the cattle was brought up on the 13th December in four trains, each conveying 30 waggons, about 24½ hours being allowed for the journey, or an average of about 21 miles an hour throughout. It must be borne in mind that these were special trains, having to thread their way through the ordinary traffic at a time, just before Christmas, when it is abnormally heavy, yet of the four trains two came in a minute or two before time, one was only a few minutes behind, and only one of the four was a couple of hours late. The west coast companies may well look upon this as a piece of good work.

However, to return to the comparison of speed, if the London and North-Western do not, as I have said, claim to run their trains at the greatest possible speed, they can still, according to our authors, point to a good record in the way of express running, for they have no less than 135 trains daily running at an average speed of 41½ miles, inclusive of stoppages, and the large majority of these trains run absolutely to time.

But it is not only the three or four leading companies who can lay claim to an honourable record in the way of improving the speed of their trains, for taking England and Scotland throughout, we are told that the time-tables show a total of 670 trains daily, with a mileage of 62,904 miles, having an inclusive speed of upwards of 41 miles per hour, whereas 20 years ago, or say in the year 1871, on the 10 leading railways of England, there were no more than 57 trains run at a speed exceeding 39 miles an hour, while none of the lesser railways could boast of any such trains.

If we now turn from the English railways to their neighbours on the Continent we shall find that the lengths to which the English companies have proceeded, under the stress of competition, in making concessions to the public, have had the effect of placing railway travellers in Great Britain in a most favoured position, as compared with the public who use the continental railways.

It is not too much to say that trains running at anything like the rates of speed in vogue on the best English railways are practically unknown in any other country of Europe. The nearest approach to them is shown in France, where the Northern Railway have a certain number of trains running at an average speed of 36 miles an hour, the Eastern Railway have a few at 34½ miles an hour, and the Orleans Railway have twelve trains between Paris and Bordeaux at 35½ miles an hour. The so-called express trains of the other French companies are run at an average speed of less than 32 miles an hour, and the express trains of Belgium at precisely the same average speed, while those of Holland very slightly exceed it. On the railways of North Germany there are some forty trains which attain a speed of between 34 and 35 miles an hour, but the remainder, even those which claim the title "express," do not exceed an average speed of 32 miles an hour, while many do not exceed 29 miles. On the South German and Austrian railways the speed of the express trains varies from 29 to 34 miles an hour, with very few exceptions. On the Italian lines there are no trains which exceed an average speed of 31 miles an hour, and in Russia the highest limit is 29 miles. Even the Orient express, one of the most famous of continental trains, although it runs through France at a speed of 37 miles an hour, travels at so much slower a rate on the other portions of the route that the entire journey from Paris to Constantinople is only accomplished at an average throughout speed of 27 miles an hour; whereas if it travelled at 40 miles an hour, a speed commonly exceeded on English railways, there would be a saving of no less than twenty-two hours in the journey. In the same way, it has been calculated that if a passenger travelled from London to Berlin, *viâ* Calais, at a speed of 40 miles an hour, exclusive, of course, of the sea-passage, there would be a saving of between ten and twelve hours as compared with the existing service.

It must be borne in mind, moreover, that all express trains on the Continent are not open to third-class passengers, while many of the best trains are actually restricted to first-class only, and the unhappy third-class passenger must put up with a rate of speed which would be perfectly intolerable to English travellers of the present day. Again, while the English companies place the most luxurious accommodation in their trains at the disposal of the first-class passenger for a very trifling sum in addition to the ordinary fare, and in some cases without any addition whatever, for the use of the *trains de luxe*, abroad an extra charge is made so high as to be prohibitive to any but the wealthiest class of travellers. For instance, from London to Perth a sleeping berth costs 5s. over and above the fare, the distance being 450 miles, while on the journey from Paris to Avignon, a distance of 461 miles, the same accommodation would cost from 36s. to 48s.

As regards the speed of the trains, it is an undoubted fact that the type of permanent way generally in use on the continental railways, which is of a lighter description than that adopted by English railway companies, and of a method of construction long discarded by English engineers, is unsuitable to bear the enormous strain of long and heavy trains running over it at the high rates of speed which prevail with us, but if it be asked generally, what is the reason that the continental railways are so much behind our own, not only in speed but in progress, in studying the interests of the public, and more particularly of the masses? the answer will undoubtedly be found in the wide difference in the conditions under which the railways have been constructed and are worked. Most of the railways in Germany, Austria, and Belgium are either State railways or are controlled by the State, and are worked not only for the benefit of the travelling public but with a view to the improvement of the State revenue, and in France, although the principal railways have been constructed by private companies, it has been done upon a system of territorial concession for a period of time, the State reserving a control over the fixing of the rates and charges, so that the question of competition seldom arises. In England, on the contrary, the Legislature has fostered the principle of competition by sanctioning the construction of alternative routes between most points of importance, and it must be confessed that a great deal of the readiness of English railway companies to yield to the increasing demands of the public, and to proceed rapidly from one concession to another, has no doubt arisen from the peculiar nature of the traffic of a country of limited extent, and where the business is so extremely competitive. For instance, between London and Liverpool, Manchester, Leeds, Edinburgh, Glasgow, Perth, or Aberdeen, and between Liverpool and Manchester, there are no less than three rival routes open to the intending traveller; between London and most of the principal places in the West of England, two routes; and so on, more or less, throughout the country. Thus, between all the principal towns there are running daily large numbers of express trains by the different routes, very often at the same hours, or nearly so, and in most cases at the same speed and fares, so that the traffic is acutely competitive, and the general conditions being so equal, it requires but the smallest inducement to influence the travelling public in their choice of route, so that there is a constant temptation to the competing companies to make fresh concessions, in order to attract business from their rivals.

A careful series of statistics which have recently been prepared, but with the details of which I will not trouble you, has shown that the practice adopted for the first time, as I have said in 1872, of attaching third-class carriages to all trains, has had the effect of causing the trains as a whole to be less profitably utilised as to space; and as the trains cannot be indefinitely increased in length and weight, this has entailed the running of an amount of additional mileage out of all proportion to the natural increase in the business. For instance, on the London and North-Western Railway, during the eighteen years which elapsed between 1870 and 1888, the amount of revenue derived from passenger traffic increased by 44 per cent., but the passenger-train mileage increased by 61 per cent. This increase of mileage, added to the greater weight and higher rate of speed of the trains, has had the effect of very seriously increasing the cost of locomotive power, so much so, indeed, that I find that during the eighteen years in question the amount of fuel consumed on the London and North-Western Railway has increased by 142 per cent., or in more than double the ratio of the increase of train mileage, showing the unmistakeable effect of the increased speed and the heavier weights to which motive power has to be applied, and this notwithstanding the improvements in engine building, and in the methods of economising fuel, which have been effected.

The exceptionally high rates of speed adopted on English railways add to the cost of working in more ways than one; in fact, they have a tendency to increase almost every item of working expenses. In the first place, there is greater wear and tear of the engines and vehicles, and more frequent repairs and replacements become necessary. Secondly, the engines must be worked at much higher pressure, and be of greater capacity, and the increased consumption of fuel, to which I have already referred, is a very serious item. Mr, Webb, our locomotive engineer, tells me that with one of his compound passenger engines, drawing a train weighing 321 gross tons, he is able to haul 1 ton of dead weight 1 mile, at a speed of 24 miles an hour, with an expenditure of 1·26 oz. of coal, but if the speed be increased to 44 miles an hour, 2·06 oz. of fuel will be required to perform the same task, so that it will be seen at a glance that speed is a very important element in calculating the cost of working. Then, again, to permit of heavy trains being run with safety at such high rates of speed, the permanent way must be proportionately strengthened, and becomes more expensive to provide and keep in repair, for it must be maintained in the most absolutely perfect condition, and the moment a rail shows signs of wear it must be taken out and replaced by a new one. The great speed at which the trains are run also necessitates a most elaborate and complicated system of signalling and interlocking, to admit of the traffic being conducted with safety and efficiency, and all this adds to the cost of the service. As an illustration, however, of how much is now demanded from railway companies, it may be mentioned that, notwithstanding all they have done, and the large sums they have expended within recent years in introducing the block telegraph system of working, in the interlocking of points and signals, the adoption of continuous brakes, and the multiplication of safety appliances, they are still considered not to have done enough; and an Act passed in the last session of Parliament conferred upon the Board of Trade new powers of control, by means of which still greater sacrifices may be imposed upon them. In virtue of those powers, the Board of Trade are now proposing to issue an order which would render it obligatory upon the companies to adopt the absolute block system upon all their lines (except very short single lines worked by the train staff or by one engine) within twelve months, and within eighteen months to interlock every station and siding upon the most improved modern principles, and to adopt continuous brakes upon every train conveying passengers, coupled with such restrictions as would practically preclude the running of mixed trains. The railway companies, as a body, have ventured to deprecate the issue of such an absolute order as this, on the ground that although the measures indicated are such as they are willing and indeed anxious to adopt, it would be almost a physical impossibility to carry them out within the limited period specified, to say nothing of the great pecuniary burden which would thus be imposed upon some of the railway companies.

There has been during recent years a very striking increase in the size and weight of the carriages employed for the conveyance of passengers, arising in great measure from the popular demand for improved accommodation, and the extent to which that demand has been conceded, and the same causes have led to a marked improvement in the arrangements for the comfort and convenience of the travelling public who use the vehicles. The standard third-class carriage of 1872 on the London and North-Western Railway, for example, was 30½ feet long and weighed about 10 tons, but the standard third-class carriage of 1889 is 42 feet in length and weighs upwards of 18 tons. The carriage of 1872 was capable of seating 50 passengers, but that of 1890 only seats 20 more or 70 in all, so that the weight of the vehicle has increased in double the ratio of the accommodation provided. To take another illustration, the standard composite carriage built by the same company in 1872, 30 feet 6 inches in length, weighed 10 tons 8 cwt., but those of the latest type, built recently, measure 42ft. in length and weigh from 18 to 19 tons. Of course the modern type of vehicle being longer, wider, and higher, than those formerly used, gives the passenger a great deal more elbow room, and being well upholstered and of handsome proportions, is more spacious and comfortable in every way.

The typical composite carriage in use upon the leading railways at the present time furnishes indeed a striking contrast to the primitive vehicles in use 50 years ago, and may be taken as representative of the latest development of the carriage builders' art in these modern times. Upwards of 40 feet in length, with accommodation for three classes of passengers and for their luggage, provided with lavatories for first-class passengers, mounted upon the easiest of springs, well lighted by gas and warmed during the winter, adorned with ornamental woods, and the handsomest upholsterers' work, and replete with every convenience and comfort throughout, it embodies in fact in a high degree the latest development of modern civilisation as exemplified in railway travelling.

But in these matters there appears to be no finality, and at the present time the principal companies are going even a step further, and are building carriages for their leading long journey trains which will provide lavatory accommodation for second and third as well as first-class passengers. Our carriage builder, Mr. Park, has furnished me with particulars of one of these vehicles now being constructed by the North-Western Company, which he informs me will weigh 19½ tons, will cost about £860, and yet will only furnish seats for 33 passengers of all classes. It is probable that some of our ingenious friends who talk learnedly upon the subject of a "ton of freight and a ton of passengers" and found all sorts of theories upon the difference of charge for the two, overlook the fact that a ton of freight means simply a ton, with a reasonable allowance for the dead weight of the waggon, whilst a ton of passengers means not merely 2,240 pounds of living freight, but something like 10 tons of dead weight in addition.

The effect of the great increase in the weight of the vehicles is seen if we come to compare the length and weight of the trains as they are running to-day with the dimensions of the corresponding trains run some years ago, and of course when trains under ordinary circumstances are of such great weight and length they cannot be easily strengthened to meet any abnormal increase of traffic or sudden pressure, and it becomes necessary, instead, to run extra or duplicate trains, thus adding in another way to the working expenses. The increase of speed has also had the indirect effect of adding considerably to the number of trains run and to the amount of train milage; in order, for example, to enable a train to run from London to Edinburgh, in the autumn of 1888, in 8 hours, it became not only necessary to maintain a high rate of speed throughout, but very few stoppages could be permitted, and other trains had to be run to serve the stations where the stoppages were dispensed with, and to enable the passengers from those stations to get on to other stations at which the train did stop.

Another innovation which, while it has had the effect of greatly increasing the weight and bulk of the trains, has largely promoted the comfort and convenience of railway travellers, or such of them as can afford to pay first-class fares, is the introduction of saloon carriages of various descriptions. Sleeping saloons, each of which is in charge of an attendant, are now run on all the more important night trains, a small fee being charged for each berth in addition to the first-class fare. Drawing-room saloons, fitted up in the most luxurious manner, are run on some of the principal day trains without any extra charge, and also luncheon and dining cars, for the use of which there is no extra charge beyond the fare and the cost of the meals supplied. With regard to the drawing-room saloons, however, it is remarkable that these are not patronised by the public to the extent which would be naturally expected, and I believe the Midland Company have had the same experience in respect of the sumptuous Pullman Parlour Cars which they run on their day express trains. It seems to be a fact that there is something in the semi-privacy of the ordinary compartment which appeals more to the taste of the British travelling public, and induces them to prefer it to the open saloons, notwithstanding their superior comfort and convenience, and the absence of any extra charge for their use. Saloon carriages are also run for family parties on any of the trains on payment of six first-class fares, or their equivalent, and also saloons for picnic parties and for invalids and their attendants. All these vehicles are of exceptional weight and dimensions; they add immensely to the weight of the trains, and are very expensive to build and maintain, and yet they accommodate but a limited number of passengers. For instance, a sleeping saloon 42 feet in length, weighing 22½ tons, and costing about £1,300, only contains berths for 16 individuals. The invention of sleeping carriages is, without doubt, a very great boon to travellers, and more particularly to business men with whom time is an object of the first importance. If, for example, in former times a London merchant wished to transact a day's business in Glasgow, Edinburgh, or elsewhere in the North, it must have been necessary for him to allot three days to the trip, as he would want a day to go and a day to return; while even if he exposed himself to the fatigue and discomfort of night travelling, a great part of the following days must necessarily be devoted to repairing the effects of the journey. Under existing circumstances, he can leave London, say on Monday night, may sleep in the train as comfortably almost as if he were in his own bed at home, devote Tuesday to his business and leave again on Tuesday night, arriving back in London on Wednesday morning, after a good night's rest, ready for the day's business. He will thus practically have only been absent from his London office for a single day

The provision of lavatory accommodation in trains is perhaps one of the greatest boons that has ever been bestowed upon railway passengers, as everyone must admit who can recall the miseries of a long journey by train on a hot summer's day after a spell of dry weather, and with no opportunity of removing the stains of travel before reaching their destination. This great convenience to the public, however, entails upon railway companies a heavy sacrifice in space and in the haulage of dead weight, in proof of which it will be sufficient to mention the fact that a first-class carriage of the largest size, 42 feet in length, which, under ordinary circumstances would provide seats for 40 passengers. when the necessary space for lavatories has been abstracted, only affords accommodation for 28 passengers, so that practically one-third of the seat space is lost and the weight of the train is correspondingly increased.

To keep pace with the increased weight of the vehicles, the power and weight of the engines employed to draw them has had to be correspondingly augmented. The most powerful passenger engines in use on the London and North-Western Railway in 1872, having driving-wheels 7 ft. 6 in. in diameter, weighed, without tenders, 27 tons 1 cwt.; but the compound engines now being made by Mr. Webb at the Crewe works, having triple cylinders and driving-wheels 6 ft. in diameter, weigh 42½ tons; while an even more powerful type of engine, on the compound system, having 7 ft. driving-wheels, weighs no less than 45½ tons, or with the tender attached upwards of 70 tons.

There are many minor additions which have been made to the comfort and convenience of those who travel on railways, to which we have so soon become accustomed that we are apt to forget that we did not always enjoy them. Amongst these may be reckoned foot-warmers, curtains to exclude the sun (what little we see of him), door and windows so constructed as to exclude, and not to admit, draughts, nets in which we can deposit our parcels, and other small *impedimenta*, instead of nursing them or thrusting them under the seats as we once had to do, and racks for our hats. All these little privileges, too, are bestowed not merely on the first-class passenger, as would once have been the case, but upon all classes alike.

Another institution is the luncheon basket It is not every traveller who is constitutionally fitted to grapple with the difficulties of a luncheon consumed in a railway refreshment-room during the few minutes that the train can be allowed to stop for the purpose, but by the device of the luncheon basket the traveller who so wishes can procure at any of the larger stations a substantial luncheon, either hot or cold, with wine or beer and all the necessary conveniences, and this he can consume at his leisure as he speeds on his journey, putting out the empty basket at any station at which the train stops afterwards.

Another very great convenience is the railway family omnibus. Anyone who has lived in a country place, or in the suburbs of a large town, before the era of the railway omnibus, must have experienced the difficulty and expense of procuring conveyances to take them and their luggage to and from the railway station, while even in large towns, where the harmless necessary "growler" is readily procurable, a family party bound for the seaside, with large quantities of luggage, would frequently require two or three vehicles to convey them all to the station. But now all that is necessary is to send a telegram or postcard to the station-master, and punctually at the appointed hour a roomy and commodious vehicle, vastly more comfortable than any four-wheeled cab, makes its appearance, and for an extremely moderate charge—so moderate, indeed, as to be barely remunerative—takes the entire party, with all its *impedimenta*, and deposits them at the station, while on their return a similar conveyance can meet them at their journey's end and take them to their home.

There is one respect in which the travelling public of to-day have an inestimable advantage over that of an earlier generation, and that is in the greater immunity from accident that they enjoy. It is hardly possible to exaggerate the importance of this point, for although speed and comfort may be very desirable, yet safety of life and limb is, after all, the paramount consideration.

It is often said that figures may be made to prove anything, but certainly if there is anything that figures do prove beyond the possibility of a doubt, it is that railway travelling has, during the last twenty years, become in a remarkable degree safer than it was, and may, indeed, be said to be now the safest mode of progression known to mankind, there being more danger actually in crossing the streets of a large town than in riding in an express train. This result has been achieved, of course, by means of the multiplication of safety appliances, the block telegraph system, the interlocking of points and signals, and the application of powerful continuous brakes to trains, and it should be borne in mind that it has been brought about in spite of the increase in the speed of the trains, which might be thought to tend in the opposite direction. In the year 1888 there were carried upon the railways of the United Kingdom upwards of 742,000,000 of passengers, exclusive of the enormous number of journeys performed by season-ticket holders. During the year, 11 persons only lost their lives by reason of accidents to trains, and 594 were injured from the same cause, so that only about 1 passenger in 67,000,000 was killed, and 1 in about 12,500,000 was injured. Now if we turn back to the year 1870, the first year in which the Board of Trade returns were published in their present complete form, we shall find that although the number of passengers carried was less than half—say about 307,000,000, the number killed in train accidents was 90, besides 1,094 injured—so that one passenger in abcut 4,700,000 was killed, and one in about 280,000 was injured. These figures speak highly for the improved safety of railway travelling, but almost as significant a result is obtained if we come to compare the amounts paid by railway companies for compensation for personal injury or loss of life with the sums paid by them under the same head at an earlier period, and Mr. Haggard, of Tunbridge Wells, a gentleman who is very much interested in railway statistics, has recently favoured me with some calculations of his bearing upon this subject which it may be worth while to quote here.

In 1868, Mr. Haggard finds that the railway companies of the United Kingdom paid in compensation £306,442, while in 1888 this amount had fallen to £102,727, or just about one-third. But in the meantime the passenger train mileage run upon railways had grown from less than 75,000,000 of miles to upwards of 155,000,000, or in other words had more than doubled, so that the average payment for every 100,000 miles run was reduced in the 20 years from £409 to £66.

Although the result shown by these figures is extremely gratifying, yet railway companies are far from taking the view that nothing more can be done to reduce railway accidents to a minimum. On the contrary, the subject is one of the greatest anxiety to them at all times, and whenever a mishap does unfortunately occur, the circumstances attending it are most keenly inquired into, in the hope that out of evil may come good, and that some lesson may be learned from the calamity which may be taken to heart and used to prevent a recurrence.

There are many ways in which railway companies, in the natural desire to increase their business and improve their revenue, confer very substantial benefits upon the community, and not the least important of these is the universal practice of issuing season tickets. The object the companies have in view is, of course, to build up and encourage a residential traffic in connection with all the large towns upon their systems; but the advantage to the city merchant or clerk in being able to escape from the smoke and din amidst which his business is pursued, and to pass his hours of rest and leisure amidst the purer and healthier surroundings of the country or suburbs, is very great indeed, and but for the concession of the season ticket this would be a thing impossible for any but those possessing large incomes, since the cost of daily railway travelling, paying the ordinary fares, would constitute an addition to their expenses not to be contemplated.

Another great boon to the public is the tourist ticket — the advantages of which to those who, in the holiday season, seek health and recreation at the many places of resort around our coasts and elsewhere are very great. In many cases tickets are issued for what are known as "circular tours," and the nature of these can best be described by means of an illustration. For a sum of just over £4 a passenger can obtain a ticket entitling him to travel from London to Carmarthen, thence to Tenby and back, then northwards to Aberystwith, thence to Dolgelly and Barmouth, thence to Portmadoc and Carnarvon, Carnarvon to Bangor, Bangor to Chester, and so back to London. This is what is called the "North, South, and Mid Wales Circular Tour," and practically it means that the holiday-maker for about £4 gets a free run over nearly all the railways throughout Wales, with all its glories of sea, mountain, and river for two months. If anyone were to perform such a tour as this and to pay the ordinary fares from point to point, he would be in a position to appreciate the pecuniary advantages of the tourist programme, especially if the fares paid were not for a solitary passenger but for a family party.

Then, again, in order to bring holiday travelling for shorter periods within even the modest means of the toiling millions, excursion trains at extremely low fares, are run frequently during the summer, and at Easter and Whitsuntide, between all the large towns, and from large centres of population to the seaside resorts, and as these trains are for the most part run during the night, they enable the artisan who can, perhaps, only afford to lose a single day's wages, to spend the whole of that day at the seaside, or amongst his friends in some far distant town. It will afford some idea of the extent to which advantage is taken of these exceptional facilities, to mention the fact that during nine months of last year the London and North-Western Company, alone carried considerably more than 1,500,000 excursion passengers.

Although perhaps not quite germane to my subject, it may not be out of place to refer to one respect in which the railway companies render a great service to the public, although like many other things, it has come to be looked upon as very much a matter of course. I allude to the marvellous facility with which the railways enable the Post-office to perform its functions. You post a letter or a parcel in London, say, at 6 o'clock this evening, and to-morrow morning your friend in Carlisle, Edinburgh or Glasgow, finds it on his breakfast table. When one thinks of the many long miles between the sender and the receiver, and how long it would once have taken to cover them, this seems almost to resemble a conjurer's feat, and certainly it can only be beaten by electricity itself. The manner in which the duties of the Post-office are performed in this country is a theme of common admiration, and deservedly so, but few of those who eulogise the Post-office, and the way in which its work is carried on, realise that it is only the perfection of our railway system that has enabled such splendid results to be attained, and that indeed it is only the existence of that system that has rendered the Postal service, as we know it, a possibility at all. Mr. W. M. Acworth, in his recent work, entitled "The Railways of England," has given so graphic a picture of the manner in which the mail service is conducted; of the innumerable cross-country trains which join the great trunk mail routes at the appointed junctions in the dead of night, and safely and punctually exchange their precious freight; of the ingenious apparatus by which mail bags are taken on board or cast off at the various stations and junctions while the trains speed on their journey without pausing for an instant; and of the busy interiors of the mail carriages where the clerks perform their duties of sorting and making up the bags while the trains are on the way, that I could not hope by any words of mine to improve upon it. But the "proof of the pudding is in the eating," and it can hardly be gainsaid that the mail train service of this country, as performed by the railway companies, as a whole, furnishes results which leave little to be desired, and which could hardly be much improved upon.

The parcel post, compared with its elder brother the letter post, is as yet but in its infancy, but it has almost at a bound become one of the great institutions of the country, and has clearly justified its inception. This service again, which is evidently so highly appreciated by the public, would be impossible but for the facilities afforded by the railway system, and the railway companies, so far from showing any unworthy jealousy of a new establishment which they might not unreasonably expect to rob them of a lucrative branch of their business, have from the outset given it a loyal support, and done their best to contribute to its success, although it has had the effect of greatly adding to the weight and bulk of their trains and the difficulty of getting them away from the stations and junctions with punctuality. This it will not be difficult for you to believe when I mention the fact that during the past year the railway companies of the United Kingdom have carried for the Post-office something like 34,000,000 parcels. Indeed, one effect of this great influx of parcels, so far as the London and North-Western Railway is concerned, has been that the time-honoured "limited mails" have had to be disestablished as passenger trains, and since July, 1885, have been run as postal trains exclusively, other trains having been run in lieu of them for the conveyance of passengers to and from Scotland.

In addition to the special postal trains to and from Scotland, which travel between London and Carlisle at an average speed of 46 miles an hour, the London and North-Western Company run no less than four other important mail trains daily to Scotland, and two in the opposite direction, besides the two up and two down Irish mails, and numerous other mail trains, but at exceptionally busy times even these are found to be inadequate, and at Christmas, when the parcels post business, to say nothing of the mails, is swollen to abnormal proportions, it becomes necessary to adopt extraordinary measures to cope with the emergency which arises. The up and down special postal trains are duplicated throughout, as well as some of the other trains, extra vehicles are attached to all the more important mails, the timing of the trains has to be altered, and generally the whole of the service throughout the system has to be strengthened and rearranged, so as to meet the great strain that is imposed upon it, and which taxes to the utmost extent the resources both of the company and the Post-office.

There is one other respect in which the railways of this country may some day prove to be its salvation, although I fervently trust the occasion may never arise. If ever so great a calamity should overtake us as that a hostile army should be permitted to set foot on our shores, it is quite evident that the prospect of our being able to repel the invaders would largely depend upon the perfect efficiency of the great network of railways which covers the country.

I believe that, thanks to our insular position and powerful navy, such a contingency is remote, but it has not been altogether lost sight of, and if it should ever arise the railways would be given up, so far as need be, to the service of the State, and would be worked, under the direction of the military authorities, by a body of railway managers and engineers, which exists under the title of the "Engineer and Railway Volunteer Staff Corps," of which I have the honour to be a member.

In a lecture which I delivered at the School of Military Engineering at Chatham in March, 1888, I gave some particulars of an interesting "Exercise" which was carried out some time ago by the officers of the Railway Staff Corps under the directions of the Commander-in-chief, and which was designed to show (and in fact did succeed in showing) how it would be perfectly easy to concentrate a force of 130,000 men, brought from all parts of the country, with all their stores and munitions of war, upon a given line of defence within less than 48 hours. This alone would be sufficient to prove, if proof were needed, that railways have revolutionised the conditions of modern warfare very much as they have revolutionsed everything else.

In nearly all continental countries great importance is attached to the organisation of railway transport in time of war, and in Germany, Austria, Hungary, Belgium, Italy, and Switzerland, central bureaux have been established which, under conditions which vary somewhat according to the circumstances of the different States, control, even in time of peace, the distribution and supply of rolling stock on all the railways throughout the country, while in each of the States I have named, and also in France, there exists some system of organisation by means of which the military authorities would in time of war take possession of the railways and work them for purposes of transport.

There is no doubt, however, that if the emergency should ever arise, the railways of this country would be found equal to the task which would be set them, and that they would be worked as efficiently for the purposes of national defence as they are, in more peaceful times, in the interests of the trade and commerce of the country.

It may here be of interest to mention a little pamphlet, published by Major-General Paget a couple of years ago, which contains what I cannot help thinking is a very useful suggestion with regard to national defence, although I am not aware that it has up to the present time borne fruit. He alludes to the fact that arrangements have been made for the registration of horses available for military purposes in the event of an emergency; but that no similar organisation exists with regard to the supply of carts and waggons for road transport, which would be one of the most essential requirements of an army in the field. What he suggests is, briefly, that a volunteer waggon train, somewhat on the lines of the volunteer force, should be formed, and that railway carmen, farmers, and others skilled in driving should be enrolled therein; an adequate number of carts and waggons employed for civil pursuits throughout the country being classified, and registered, and subsidised by the Government so as to be available in case of need. It is not necessary for me to go into the details by which he elaborates his scheme, but there can be no doubt that some such organisation as this would form an invaluable adjunct to any scheme of national defence.

I am far from believing that my subject is exhausted, for there is much remaining that might be said; but I have already exceeded the limits of the time and space allotted to me and must draw to a close, but before doing so I may perhaps be allowed to point the moral of my tale—if moral there be.

Railway companies are, beyond a doubt, about the best abused body in the community, not excepting even that universal scapegoat —the metropolitan police. There is a great tendency to regard them as grasping monopolists, pursuing only their own selfish advantage at the expense of the community; but all this is hardly deserved. Monopolists, as I have just shown, they are not and cannot be, except in isolated cases, and although it is perfectly true that they pursue their own advantage, which, as business men, they are quite justified in doing, it is an elementary fact, to which no one is more fully alive than they are, that in the long run the public interest is theirs, or rather, the two are inter-dependent. It is the object of the merchant not only to sell his wares to the best advantage, but to sell as many of them as possible, and it is the same with the railway companies. Whatever will induce people to travel more frequently and will promote the circulation of goods traffic throughout the country increases their revenue and the profits of their shareholders, and advantages judiciously offered to the public within reasonable limits are as the seed that produces the harvest.

It is said to be an Englishman's privilege to grumble, and certainly he exercises this privilege without stint so far as the railway companies are concerned. The merchant whose goods are a few hours late in delivery, roundly abuses the railway company, unheeding of the fact that they have arrived punctually nine times out of ten, and not knowing that, perhaps, the train which carried them on this particular occasion may have had to grope its way for hundreds of miles through a dense fog, or that they may have lain in the hold of a steamer which has fought its way across the channel in the teeth of a violent storm. The passenger whose train is half-an-hour late in reaching its destination on one occasion in ten is unsparing of his censure, although, if he only knew it, the delay has arisen from some perfectly unavoidable cause, or has been incurred from a due regard to his safety and that of his fellow passengers.

The policy of railway companies finds many critics, but on the whole it is probable that if the circumstances were as well understood by the public as they are by themselves, it would be apparent that, after all, they know more of their own business than could be taught them by some, at least, of their censors.

If I have made use of the opportunity thus afforded me to such effect as to induce you to realise more fully the advantages which are derived from the railway system by the population of this country, and to bring you to believe that John Bull, after all, has cause to be proud of his railways, especially when he looks abroad and compares them with those of his neighbours, my object will have been sufficiently attained, and I shall not have addressed you in vain.

DISCUSSION.

The CHAIRMAN thought the moral to be drawn from the paper was that they ought to be grateful to Parliament that it had never embarked upon any of the schemes of railway purchase by the State which had been so often discussed in that room, and which at one time were very popular. There had been more improvements on English railways than on continental lines which were under State control, and the Post-office was a striking instance of the immobility of a great establishment under Government control. Shortly after the introduction of the penny post, a number of improvements were introduced by the Post-office authorities, and then things seemed to stagnate until the introduction of the parcel post, which was really brought about by railway competition. If the State had purchased the railways they would no doubt have had a good railway system formed, but after that had been done things would have been allowed to remain in *statu quo.* He could remember the time when railways were first introduced, when the carriages took their shape from the old stage coach. The Americans, no doubt, had taken their idea of a carriage from the steam boats by which they had been accustomed to travel, and these long and comfortable cars were at first somewhat in advance of the English carriages, but now the English companies had more than caught up the Americans in this matter. He agreed with Mr. Findlay that Englishmen preferred smaller carriages, with the comparative privacy, to the large carriages in vogue on American railways. He was glad to hear that lavatories were now being introduced on English lines.

Mr. C. A. PARK briefly explained the construction of the different kinds of coaches in use on the London and North-Western system, diagrams of which were exhibited. In the dining saloon carriage the system of cookery by gas had been adopted with the utmost success. A sleeping saloon was supposed to carry sixteen people, but it really only carried eight, as the public would not use the upper berths. Each compartment was fitted with lavatory accommodation. The sleeping saloon was a work of art, and cost a considerable sum; but it really amounted to this, that a large sum of money was spent for the purpose of providing accommodation for practically only eight persons.

Mr. T. C. TOWNSEND thought that trains in this country should be so arranged that there should be an uninterrupted communication from the engine to the rear of the train. He had travelled on the Continent, and found that even in Russia this plan was adopted, He hoped that those who had charge of the construction of railway carriages would in future keep this point in mind, believing that if some such plan as he had suggested were adopted, outrages upon passengers would become a thing of the past.

Mr. A. B. W. **Kennedy**, F.R.S., referred to the excellent train service of the London and North-Western, by which a person might go to Glasgow and return, spending only one night in the car, which, considering the distance was over 400 miles each way, he considered to be an excellent performance. The paper alluded to a popular belief which he thought ought to be contradicted, viz., that there was only one class on American lines. This was pure imagination. The local trains, it was true, had only one class, but all important trains had two classes, and the very important trains had three classes. Travelling at night was much more comfortable on English lines than American lines, the American Pullman cars being very disagreeable to Englishmen, as there were twelve double berths in each car, and the conductor had strict orders to pull down the upper berth at all hazards. On the English lines there were only eight people in each compartment, and every one would admit that it was more comfortable to be in a little cabin with only one other person than in a large room with eight others.

Mr. J. S. **Jeans** said he had listened to the paper with feelings almost of envy and despair, for it had been his unfortunate lot for 40 days to attend the Board of Trade inquiry that was now proceeding. He thought that a good many of the advantages and privileges that had been referred to, and the improvement in rolling stock, &c., were likely to be purchased at the expense of the goods traffic of the country. He could only hope that this would not be so. He could endorse what had been said with regard to the superior facilities afforded for passenger and goods traffic in this country as compared with the continental lines, but these facilities had been purchased at a great cost. The mileage cost of English railways was considerably more than double that of other countries, with the exception, perhaps, of France and Belgium; the average cost being £50,000 per mile. This made it necessary that the companies should be in a position to make charges in excess of those upon continental railways, but whether the margin was not greater than it ought to be, in the interest of the traders, was a point which was fairly open to question. Some years ago he had an opportunity of reading before the Royal Statistical Society a paper on the working of railways, in the course of which he pointed out that third-class traffic was really the backbone of any railway, and the figures he gave showed that the first-class traffic, as a whole, if not conducted at actual loss, was not conducted at anything like adequate profit. His opinion was that the first-class, and, to a certain extent, the second-class traffic, was conducted at a loss, that is to say, having regard to the limited extent to which the first and second-class carriages were utilised, he did not believe that the facilities afforded to the passengers in those classes was remunerative. The railway companies took credit to themselves for the facilities afforded in recent years to third-class passengers, but the result had justified the course which had been taken, as the third-class passenger-traffic was enormously greater in England, in relation to the population, than in any other country in the world. Whether this development would have taken place had these facilities not been afforded was very doubtful. He had recently been looking over some returns of first, second, and third-class travellers in continental countries, and he found that in France, Belgium, and Germany the third-class ranged between 45 and 60 per cent. of the whole. On the Continent, returns were made of the average number of places provided and occupied in trains, from which it appeared that the number provided was from 42 to 45, and those occupied from 20 to 27.

Mr. **Parker** thought a great boon would be conferred on the working classes if railway companies would extend the system of season tickets to third-class passengers.

Mr W. **Storr** said that some companies might take credit for the better lighting of their carriages at night, but other companies appeared to "love darkness rather than light." Credit might also be claimed for the metropolitan extensions, by which access had been given to main lines without driving to the great terminal stations. It was gratifying to hear of the diminution of personal risk in travelling, but it would have been still more gratifying if a similar assurance could have been given with respect to railway servants and the dangers to which they were specially exposed. One of that night's newspapers contained a letter signed "A Doomed Shunter," who said that, as railways were now worked, every shunter was certain of being killed or mutilated before the close of 1899, and who asked whether railway managers ever meant seriously to try to obtain an automatic coupler, so that the writer might "not have to fight death," as he declared he did in his daily work. The Chairman had become spokesman for John Bull, to whom Mr. Findlay appealed "to be proud of his railways," which were managed by companies who knew "their own business," and professed that "in the long-run" their interests were those of the community. It was material improvements rather than principles of management they were asked to discuss, but within the limits of that paper it was quite possible to discount the blessing attributed to the competitive principle. It was stated that abroad railways were managed, not only for the benefit of the travelling public, but also with some regard for statesmanship, so that in those cases the interests of the community were substituted for those of private shareholders. Suppose Mr. Findlay, instead of managing a large company, held an office analogous to that of Postmaster-General; suppose he had held such an office for fifty years or more; would he, in laying out the railways of the country, have proposed to adopt the competitive principle? Would he have taken the most remunerative routes that could be selected and said that they should be managed independently? Would he have said that the sparsely populated districts should have only such railway accommodation as their traffic would be likely to sustain without being assisted by the more profitable traffic of adjoining counties? Would not a Railway Master General, like a Postmaster-General, have looked at the country more as a whole? Would he not have avoided the needless and costly railway of express trains competing for the through traffic? Would not the trade of the country have run in natural channels if its requirements had been provided for without the friction caused by the efforts of competing companies to divert it? There was stagnation enough in telegraphing while the work was in the hands of two companies. The expansion that followed the transfer to the State far surpassed anything that had been dreamed of by the companies. They literally checked the growth of the newspaper Press, which dated its most marvellous development from the acquisition of the telegraph by the Post-office. In the Parcels Post we had the co-operation of the State with the companies; but, as to the sacrifice of the companies, why the carriage of parcels between the large towns, in which the companies could easily deliver them, was the most profitable part of the business, and the collection and delivery of parcels in the rural districts, which the companies left to the Post-office, was the most costly and least remunerative part of the work. All credit to the companies for loyal co-operation, but let it be seen that the Post-office was handicapped, so far as there was competition, by embracing country as well as town. And let it be remembered that on the high road between London and Brighton, good horse vans were running with post parcels, because the work could be done in this way cheaper than by railway. John Bull did not now believe that dividend-paying companies identified their interests with his own, and he believed that the railways might have been laid out and worked so as to give to the public greater boons than had resulted from selfish competition.

Captain FAIRHOLME referred to the way in which the Prussian Government were opening up the country by means of short local lines (*chemins de fer vicinaux*), and stated that to his knowledge enormous sums had been spent in this direction during the last twelve years. This kind of thing was absolutely impossible in England, owing to the difficulties thrown in the way by Board of Trade regulations. He considered that the English railways might be improved in many respects.

Mr. J. W. BATTEN did not think that the English companies had better carriages, appliances, or methods of working than those on the Argentine railways. In the Argentine Republic a plan was adopted which might be recommended to the great English companies, and it was this, that speed and luxury, if given, must be paid for. He considered that if he were taken in an express train from London to a distant part of the country, and could earn a day's fee by attending an arbitration or inquiry, and he brought back again at night, he owed a special fee to the company for having carried him in that way. The ordinary third-class passenger cared nothing for that sort of thing. Second-class passengers had good cause for complaint, for while the fitting up of the carriage was little better than the third-class, on a long journey the amount of fare bore a larger proportion to the cost of the carriage. The right plan to adopt was to put a small fee in addition to the third-class fare for the extra accommodation provided. If this were done the second-class would not be found to be drifting into the third-class, as was now the case. In travelling in America, or on the Continent, the universal desire was to see as much of the country as possible during the trip, and the reason why Messrs. Cook and Messrs. Gaze had succeeded so well was because they gave a tourist route outward by one company and homeward by another, and he did not see why some such plan should not be adopted by the combination of English companies. Another improvement that might be effected was in the collection and delivery of parcels in large towns, and he suggested that the companies should pool the whole of the parcel receipts and divide them in agreed proportions. They might introduce the system which was so popular in America, viz., the C. O. D., or cash on delivery. Years ago he, with others, started a company upon this principle, but it unfortunately did not succeed, owing to the enormous number of parcels sent in by a few large firms, which had to be delivered all over the kingdom. This objection did not apply in the case of railways, and if they were to combine in the matter of collection and delivery, they would not only have the carriage of the goods but would earn $2\frac{1}{2}$ per cent. upon all the parcels in addition to the receipts for carriage, which would represent an immense sum of money in the course of a year. If they did this the Post-office would soon have to follow suit, or else give up theparcel post.

Mr. MCLAUCHLAN regretted that no allusion had been made in the paper to the bad manner in which third-class carriages were formerly lighted in this country as compared with the present day.

Mr. W. G. TREWBY suggested that the companies might remove one cause for unpunctuality in the trains, especially during the tourist season, by declining to allow luggage to be carried by express trains. The luggage might be sent either by an earlier or a later train.

The CHAIRMAN then proposed a vote of thanks to Mr. Findlay for his excellent paper, and to Mr. Neele for the admirable manner in which he had read it.

Mr. G. P. NEELE said that although he held a brief to read the paper, he did not know that he held one to reply to the various observations which had been made. He quite agreed with the suggestion that trains should have through communication, and it was not much to the credit of English railways that a better system of communication had not been devised. The difficulty of properly lighting the carriages was now almost solved by the use of Pope's or Pintsch's gas. Reference might have been made in the paper to the great improvement which had taken place in stations and the accommodation provided for passengers, and also to the vexed question of the height of platforms. To his mind the perfection of a platform was where it was level with the floor of the carriage. The question of risk to workmen was a serious one, and was constantly occupying the attention of managers, and Mr. Findlay had over and over again issued circulars warning the men as to the recklessness with which they placed themselves in danger. His company insisted on the use of the uncoupling pole, so that there was no necessity for the men to pass between the wheels; but when the men had a chance of falling back upon the old system they eagerly seized it. It seemed very much as if familiarity with danger bred contempt on their part. As to State management of railways, and the redivision of England, there was really nothing in it, for it had been tried in France, and the result was anything but success. With regard to Mr. Batten's suggestion, it was useless to talk about what "might have been," but he could say that the London and North-Western had suggested the use of a common parcel label, and proposed to divide the receipts from this traffic in proportion to the parcel business done by the companies during the previous ten years, but owing to certain little jealousies the plan never came into operation. The money received by the companies from the Post-office for parcels was thrown into a common fund, and divided very much on the lines that had been suggested. No doubt at some future happy date the suggestion as to the tourist tickets might be brought about, and the C. O. D. arrangement was a practical one which might well be tried. He fully agreed with what had been said as to unpunctuality being occasioned by the luggage, and the companies had tried to impress upon travellers the importance of sending the luggage beforehand, but an Englishman did not seem to be happy unless he had his luggage with him. As to the remarks of Mr. Jeans, that improvements were likely to be effected at the expense of the traders, all he could say was that railway companies were not so foolish as to kill the goose which laid the golden eggs. The companies really depended upon the traders for the traffic of the line, and he had no doubt it would be seen very shortly that the charges made by the traders at the Board of Trade inquiry was a very weak one. The point made by Mr. Jeans as to the cost of third-class traffic was met in some passages in the paper which he had not read.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

FEBRUARY 19.—Prof. SILVANUS P. THOMPSON, D.Sc., "The Organisation of Secondary and Technical Education in London." Sir OWEN ROBERTS, F.S.A., will preside.

FEBRUARY 26.—ARTHUR MONTEFIORE, "The English in Florida."

MARCH 5.—J. TRIPPLIN, "Recent Progress in British Watch and Clock Making." Lord GRIMTHORPE will preside.

MARCH 12.—SIR DOUGLAS GALTON, K.C.B., D.C.L., F.R.S., Vice-President of the Society, "The Chemin de Fer Glissant, or Sliding Railway."

MARCH 19.—J. S. KELTIE, "Commercial Geography."

MARCH 26.—G. N. HOOPER, "Carriage Building and Street Traffic in England and France."

FOREIGN AND COLONIAL SECTION.

Tuesday afternoons, at Five o'clock:—

FEBRUARY 18.—J. HENNIKER HEATON, M.P., "Ocean Penny Postage and Cheap Telegraph Communication between England and all Parts of the Empire and America."

INDIAN SECTION.

Thursday afternoons, at Five o'clock:—

FEBRUARY 28.—WILLIAM SHERRIFF (of the Rangoon Chamber of Commerce), "The Northern Shan States and the Burma-China Railway." Sir CHARLES BERNARD, K.C.S.I., will preside.

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock:—

MARCH 11.—JAMES ORROCK, R.I., "The Claims of the British School of Painting to a thorough representation in the National Gallery." Sir JAMES D. LINTON, P.R.I., will preside.

[Pictures by illustrious English masters whose works are not included in the National Gallery will be exhibited by Mr. Orrock.]

[The date of this meeting has been changed from March 4th, as previously announced.]

CANTOR LECTURES.

Monday evenings, at Eight o'clock:—

THOMAS BOLAS, F.C.S., "Stereotyping." Three Lectures.

Lecture I.—February 17.—Historical Notes.—General considerations on the progress of stereotyping. The paper-mould process. A demonstration of the paper process in its leading features. Moulding from the type, casting, finishing.

Lecture II.—February 24.—The Paper Method.—Adaptation of the process to the various requirements of rapidity, sharpness, and hardness. The paste. The flong. Dryness of the mould. Packing the high parts of the mould. The metal. Influence of foreign admixture. Use and abuse of French chalk. Moulds for making numerous casts. The surface of the casting-box. Relation of the temperature of the metal to the dryness of the mould. Quick moulding, and drying after removal from the type. General considerations as to casting type metal in paper moulds. Damage to type in stereotyping.

Lecture III.—March 3.—Various Stereotype Methods.—Casting in plaster moulds. Survival of the method for casting from music type. The copper electrotype backed with soft metal. Casts in brass and the more refractory metals. Softer stereotypes—Celluloid, india-rubber, gelatinous compositions.

Popular Lectures.

Saturday afternoons, at Three o'clock :—

Professor Vivian Lewes, "The Atmosphere." Four Lectures.
March 8, 15, 22, 29.

MEETINGS FOR THE ENSUING WEEK.

Monday, Feb. 17...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Thomas Bolas, "Stereotyping." (Lecture I.)

Shorthand Writers' Association, Westminster Town-hall, S.W., 8 p.m. Annual Meeting.

British Architects, 9, Conduit-street, W., 8 p.m. Mr. John Slater, "Building Legislation."

Medical, 11, Chandos-street, W., 8½ p.m.

Asiatic, 22, Albemarle-street, W., 4 p.m.

Victoria Institute, 1A, Adelphi-terrace, W.C., 8 p.m. Rev. F. A. Walker, "Iceland."

London Institution, Finsbury-circus, E.C., 5 p.m. Professor W. P. Ker, "The Poetry of William Dunbar."

Tuesday, Feb. 18 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m. (Foreign and Colonial Section.) Mr. J. Henniker Heaton, M.P., "Ocean Penny Postage and Cheap Telegraph Communication between England and all parts of the Empire and America."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. G. J. Romanes, "The Post-Darwinian Period." (Lectuie V.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Mr. J. W. Hart, "The Shanghai Waterworks." 2. Mr. Jas. Orange, "The Tytam Waterworks, Hong Kong." 3. Mr. J. H. T. Turner, "The Construction of the Yokohama Waterworks."

Statistical, School of Mines, Jermyn-street, S.W., 7¾ p.m.

Pathological, 20, Hanover-square, W., 8½ p.m.

Zoological, 11, Hanover-square, W., 8½ p.m.

Wednesday, Feb. 19...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Prof. Silvanus P. Thompson, "The Organisation of Secondary and Technical Education in London."

Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Hon. Ralph Abercromby, "Observations on the Motion of Dust, as illustrative of the Circulation of the Atmosphere, and of the Development of certain Cloud Forms." 2. Capt. D. Wilson-Barker, "Cloud Nomenclature" 3. Mr. Eric S. Bruce, "An Optical Feature of the Lightning Flash."

College of Preceptors, Queen's-square, W.C., 7½ p.m. Dr. Francis Warner, "Mental Physiology—a Study of the Growth of Mental Faculty, and its Culture in Children."

Archæological Association, 32, Sackville-street, W., 8 p.m.

Inventors' Institute, Chancery-lane, W.C., 8 p.m. Discussion on "The Resolutions passed at the recent International Congress on Industrial Property; and other matters connected therewith."

Thursday, Feb. 20...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Sir John Lubbock, (i.) "The Fruit and Seed of Juglandia;" (ii.) "The Shape of the Oak Leaf; (iii.) "The Leaves of the Viburnam."

Chemical, Burlington-house, W., 8 p.m. 1. Dr. G. H. Bailey and Mr. W. B. Hopkins, "The Behaviour of the more stable Oxides at High Temperatures." 2. Messrs. G. J. Fowler and J. Grant, "The Influence of different Oxides on the Decomposition of Potassium Chlorate."

London Institution, Finsbury-circus, E.C., 7 p.m. Mr. Carl Armbruster, "Franz Schubert and his Successors."

Royal Institution, Albemarle-street, W., 3 p.m. Rev. Canon Ainger, "The Three Stages of Shakespere's Art." (Lecture II.)

Electrical Engineers, 25, Great George-street, S.W., 8 p.m.

Historical, 11, Chandos-street, W., 8½ p.m. Annual General Meeting.

Numismatic, 4, St. Martin's-place, W.C., 7 p.m.

Camera Club, Bedford-street, Strand, W.C., 5 p.m. Annual General Meeting. 8 p.m. Mr. W. K. Burton, "One or two of the tenets of the 'Naturalists.'" With Notes in reply by Mr. G. Davison

Friday, Feb. 21...United Service Inst., Whitehall-yard, S.W., 3 p.m. Rear-Admiral R. Mayne, "Lessons to be learned from Naval Manœuvres."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Mr. Shelford Bidwell, "Magnetic Phenomena."

Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. C. N. Goodall, "Some Types of American Locomotives, and their Construction."

Philological, University College, W.C., 8 p.m.

Physical, Science Schools, South Kensington, S.W., 5 p.m. 1. Mr. F. B. Hawes, "A Carbon Deposit in a Blake Telephone Transmitter." 2. Mr. A. P. Trotter, "The Geometrical Construction of Direct Reading Scales, for Reflecting Instruments." 3. Mr. A. P. Trotter, "A Parallel Motion Suitable for Recording Instruments." 4. Prof. S. P. Thompson, "Bertrand's Refractometer."

Geological, Burlington-house, W., 3 p.m. Annual Meeting.

Saturday, Feb. 22...Royal Institution, Albemarle-street, W., 3 p.m. Lord Rayleigh, "Electricity and Magnetism." (Lecture II.)

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m

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FRIDAY, FEBRUARY 21, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

Mr. THOMAS BOLAS delivered the first lecture of his course on "Stereotyping" on Monday evening, 17th inst. After dealing with the history of the subject, he described the paper-mould process, and demonstrated the practice of the paper process in its leading features—moulding from the type, casting, and founding.

In the course of his remarks on the history of stereotyping methods, the lecturer emphasised the importance of the work done by the celebrated French printer, Firmin Didot, and his associates, about the end of the last century, and the beginning of the present. Didot's methods of moulding the type forme, first by striking into type metal at the point of solidification, and secondly by forcing against a soft lead plate (type metal being then cast on this lead plate), led to Herhan's hard alloy for types (25 lead, 15 antimony, and about 6 of copper). Another step made in the same office was Guillot's "Graphitype," in which the steel type-punches were driven successively into a copper plate, this plate being then used as a matrix for casting a stereotype. Guillot's method may be regarded not only as the parent of the various "type writer" methods of making matrix sheets or strips, but also of Herhan's next introduction—the use of matrix types. Herhan's types were of brass or copper, but with a female letter at one end instead of the usual male letter, and when these were set in a forme a direct stereotype cast could be obtained. Some of Herhan's matrix formes and casts were recently in the *Conservatoire des Arts et Metiers* at Paris, and are probably still there. Mergenthaler's Linotype system was then referred to as the latest outcome of matrix setting.

The lecturer suggested that as for newspaper work the printing is now always done from stereotypes, it would be a more reasonable and direct proceeding to set the matrices and cast the required plate directly into the matrix forme, rather than to delay matters by the intermediate process of moulding. Although Herhan devised excellent methods of striking his matrix type quickly, and in true register, from the original punches, the lecturer pointed out that an engineer of the present day could do better: he could design a machine which would turn out brass or copper matrix types about as quickly as wire nails are cut off and headed, and the cost per pound of the matrix type possibly might not exceed that of ordinary types. Again, it was suggested that it would be quite easy to make the matrix types radial, so that they could be "made up" in curved casting boxes and plates for rotary machines and stereotypes cast as soon as the last lines were set or the final corrections made.

The lectures will be printed in the *Journal* during the summer recess.

POPULAR AFTERNOON LECTURES.

The Council have arranged for a course of popular lectures to be given by Professor VIVIAN LEWES, on the following Saturday afternoons at Three o'clock, March 8, 15, 22, 29. The subject will be "The Atmosphere."

The lectures will be of a popular and elementary character, and will be fully illustrated by experiments.

The regulations for admission will be the same as for the Cantor Lectures, each member having the privilege of admitting one friend.

Proceedings of the Society.

FOREIGN & COLONIAL SECTION.

Tuesday, February 18, 1890: Sir FRANCIS DILLON BELL, K.C.M.G., C.B., Vice-President of the Society, in the chair.

The paper read was—

OCEAN PENNY POSTAGE AND CHEAP TELEGRAPH COMMUNICATION BETWEEN ENGLAND AND ALL PARTS OF THE EMPIRE AND AMERICA.

By J. Henniker Heaton, M.P.

It is a privilege of considerable value to the would-be reformer, struggling against the massed forces of bigoted, self-sufficient, and prejudiced opponents, to come before such an audience as this and set forth his views *urbi et orbi*. For I may say it without flattery, the intelligence of the Society of Arts, exercised and whetted on so many abstruse and difficult problems, must be more than equal to the determination of the simple question of State economics which I propose respectfully to submit to you, and your absolute impartiality cannot be denied. Hundreds of thousands of busy citizens are content, in a matter like this, to abide by the opinion of a body composed of trained scientists and wary investigators of the truth. I ought, therefore, to express at once, and most heartily, my grateful acknowledgement of the service which you are doing—for I doubt not of your approval—to the cause of unimpeded postal and telegraphic communication between the various portions of the British Empire and the United States, as well as of the signal honour incidentally conferred upon myself.

The importance of the subject will hardly need vindication, and its urgency is equally beyond dispute. Let us glance for a moment at the present state of things. We find that the cost of posting a letter from France, Germany, or Russia to British India is only 2½d., while the charge from the United Kingdom to British India is 5d. I have handed the Postmaster-General a list of forty British colonies to which the postage from France, Germany, and Russia is half the rate charged from England. In India itself there is near the Bombay Presidency the Portuguese settlement of Goa. The postage of a letter from Portuguese Goa to England is 2½d., but from Bombay to England the postage is 5d. And, to make the case still stronger, I may point out that the postage of a letter from Bombay to Goa is only a halfpenny; so that it would be cheaper for the Briton in Bombay to send his letters for England to Goa to be posted, for he would save 2d. by the operation. Again, there is near Madras the French settlement of Pondicherry, in India, and the postage from French Pondicherry to England is 2½d., but from Madras to England the postage is 5d. Here again 2d. would be saved whenever the British inhabitant of Madras chose to send his letter to the French colony in India to be posted to England. In this case also it would be carried in a foreign mail bag, but in a Peninsular and Oriental steamer, to England. The well-known incident of an agent in London boasting that he makes £1,300 a year by posting his newspapers in France every Friday for India and the East may here be recalled; and in Shanghai and Zanzibar a letter for England costs 5d. if posted in the British post-office, but only 2½d. if entrusted to the French or German office. These are typical cases of the injustice shown by our postal authorities to Englishmen.

Now at this moment, a general, though perhaps not concerted, attempt is being made by other Powers to deprive us of our markets in partially civilised lands, and even in our own Colonies. France, with a few burdensome trans-oceanic dependencies, spends £400,000 a year more than we do in subsidising her mail-lines, and charges her merchants half the British rates for postage, and Germany and other States are equally astute. The British Post-office, to cap its record of "blundering" and "plundering," actually conveys these foreigners' letters of advice, price lists, instructions to agents, and so forth, at half rates in British ships! Thus the unfortunate British trader, competing for the orders which give bread to millions of our working classes, enters the field handicapped with British weights against his favoured rivals. This state of things must be viewed in the light of the fact that for every 10s. worth of goods which the foreigner buys from us, the British colonist buys £8 worth. This policy of hunting British trade out of our Colonies attracted, I observed, the applause of the Post-office administrators at their recent jubilee banquet, and I was not surprised. Men so devoid of the sense of humour as to celebrate the connection of the Post-office with Sir Rowland Hill's reforms are of priceless value as a relief from the dull monotony of life. Why, the Post-office accepted its mission with about as much grace and cheerful readiness as a zebra would exhibit on the first attempt to saddle him, or a porker on the insertion of a ring in his nose. The then Postmaster-General declared that "of all the wild and visionary schemes he had ever heard or read of, penny postage was the most extraordinary."

This is an Imperial question *par excellence*, and it must be treated from an Imperial point of view. Some four years ago, when I first proposed colonial and foreign penny postage to the House of Commons, I was supported by 142 hon. members, although the movement was then in its infancy. The subject was at once widely discussed in the press, and from the *Times* and other great London papers downwards, my views received hearty, in some cases enthusiastic, support. Since then I have received letters of approval from almost every part of the civilised globe. I have lived in a snowstorm of epistolary commendation and encouragement, and the Eaton-square postman, I fear, has too long had reason to wish the question well settled, one way or the other. But though I have enjoyed so much encouragement, the measure has not been carried, for the official element still remains deaf to the voice of reason and blind to the lessons of postal history. At this stage, therefore, it is possible for the redoubtable force of public opinion to be exerted with effect upon the stubborn magnates at the Treasury and St. Martin's-le-Grand. They have pooh-poohed reason and justice. I propose to bring the moral pressure of three continents to bear upon them. The tremendous force embodied in the unanimous sentiment of the English-speaking races of the earth cannot be measured or even indicated in words, any more than we can state the force of impact of a comet in foot-tons. I appeal to this irresistible power, which has more than once been invoked for the good of our common humanity-for the restraining of tyranny and stamping out of disease, ignorance, and war. Before going further, let us consider for a moment what is involved in this phrase, "English-speaking races of the earth."

The inhabitants of the British Empire number 327,000,000 and those of the United States 60,000,000—in sum 387,000,000. The number of free and fairly educated human beings is probably less than 200,000,000, and of these the British Empire and the United States claim at least 120,000,000. The class of "English-speaking and English-governed" includes two-fifths of the population and three-fifths of the intelligence of the world. The British possessions measure 9,000,000 square miles, and the United States 3,500,000. But the mere area of the two territories does not suggest their real magnitude and importance.

As might be expected, our English-speaking race, which has had several centuries' start in the business of colonisation, has sought out and appropriated long ago nearly every spot that is fertile, pleasant, or strategically important on the earth's surface. It is almost pitiable to see the French fighting for a steaming morass like Tonquin, and the Germans intriguing for supremacy over a barren waste like Damaraland, simply because there is nothing better to be had than our leavings.

English and American merchants almost monopolise remunerative international commerce. Of ten ships encountered on the sea, nine must be hailed in our mother tongue. The English mercantile marine comprises, in all, 21,896 vessels, but it must be remembered that a vast amount of American goods is carried in British bottoms. The revenue of the Queen's dominions is £200,000,000, of which the British Isles contribute only £90,000,000. Our manufacturers sell every year to the Colonies goods to the value of £153,000,000, and we import colonial produce to the annual value of £138,000,000. Poor British emigrants, hampered as they are by postal exactions, send each year to still poorer relations in the old country £2,500,000.

The Imperial ensign flies on some 500 ships of war, manned by 100,000 seamen (nearly as many as are included in three German army corps, on a war footing) and to these must be added a huge fleet of 500 steam clippers, such as the German Emperor inspected the other day, available in case of war as cruisers and transports, and meanwhile occupied in our colonial trade.

Go into one of our magnificent harbours, and note the long lines of huge British galleons lying at the wharves. While you look, there are lying at other ports in other climes all over the world, countless sister ships flying the same old flag, Far to the frozen north the skin-clad labourers toil down to the quays for us with the produce of their national industry. To the south, on the equator, under a blazing sun, long lines of strange swarthy porters, jabbering antique guttural tongues, bring such burthens as their slighter frames will sustain to fill the capacious British holds yawning to receive them. Still farther southward, at the stormy Cape, and all round the vast extent of the Australian coast-line, still you find the flag that Drake and Nelson flew, still you hear the language that is spoken in the streets of London and Washington.

American commerce, too, is fast assuming gigantic proportions. With their wide domain of 3,500,000 square miles, stretching over a temperate latitude, nourished by noble streams, and rich in mineral wealth of every decription, and with their far-famed energy and determination, the Americans are able to maintain a leading place in all the important markets of the world. I observe that their total imports and exports for the year ending in June, 1888 (exclusive of specie), amounted to the astounding sum of $1,407,819,218. Every economic disturbance in the States is of course instantly felt in other countries.

It is often gloomily predicted that such a tremendous agglomeration as the British Empire will inevitably fall to pieces and dissolve like its predecessors. "Where," it is asked, "are the Greek, the Roman, the Spanish, the Napoleonic empires?" I venture to reply that, in the postal and telegraphic services the empire of our Queen possesses a cohesive force which was utterly lacking in former cases. Stronger than death-dealing warships, than devoted legions, than natural wealth, or wise administration, are the scraps of paper that are borne in myriads over the waves, and the two or three slender wires than lie hidden in the fathomless depths below. Not a misfortune, or cause of rejoicing, of hope, astonishment, or apprehension can occur in any portion of the empire without a thrill of sympathy vibrating through the mass. The telegraph and the mail lines are the nerves and arteries of the whole, and there is just the same difference between the empire of the Cæsars and that of our sovereign as between a bronze statue and a living man.

It is interesting to notice that the British Isles form geographically the centre of the entire world system of trading communications. Placed on the western edge of Europe, in the North Atlantic, the British ships readily attain the American shores, and coast the great African continent to the southern seas. We all know what facilities the Suez Canal has secured for our commerce, and the same result will accrue to us from the projected waterways across Central America and France. It might be objected that we are ill-placed for communicating with Asia on its eastern border. But the Canadian Pacific Railway has so greatly shortened the journey to China and Japan that, to reach the East from England, paradox as it may appear, the quickest way is to travel to the west. Putting imports and exports together, the total foreign trade of the United Kingdom was—

In 1887	£642,990,725
In 1888	685,520,679

An increase in 1888 of £42,530,254.

Of this increase no less than £6,334,000 represents increased exports to Australia. Our own colonies are our best customers, and buy more largely of us every year. The Empire embraces territory in almost every quarter of the globe; it includes whole nations professing diverse and sometimes even hostile faiths. It shelters and fosters three-fourths of the world's commerce. The wealth, extent, complexity, and populousness of it are simply bewildering.

Now in these qualities of the Empire lies the danger that threatens its existence. Every soldier knows that it is much easier to conquer an army broken up into detachments than one collected in battle array. The several countries or members, which make up the Empire, are separated materially by the ocean and intellectually by conflicting beliefs, habits, and interests. The most elementary notion of statesmanship would indicate the urgent need of welding together these isolated groups of humanity by promoting every kind of communication among them, acquainting each with the feelings, wishes, and circumstances of the rest, circulating common aspirations, and creating a sentiment of solidarity and mutual trust. "Shoulder to shoulder" the Queen's subjects might fearlessly meet the world in arms, and the dispatch of Indian and Australian troops to Malta and Egypt was among the most momentous events in British annals.

What more simple, inexpensive, and effectual means of attaining these ends can be suggested than that of facilitating intercourse—postal and telegraphic intercourse? The towering edifice of empire must be strengthened and consolidated with the cement of sympathy, otherwise it is a tottering pile of loose stones, a ninepin for the diversion of our enemies. Yet what has been done to win and retain for the "old country" the affection and interest of the many millions of emigrants that have quitted its shores, say, during the past generation. Each one of those emigrants leaves a circle of loving friends in the United Kingdom, and during his lifetime any news of that circle is sweet and precious to him; while they at home long to hear of his struggles and successes. But, unfortunately, the bulk of these emigrants are poor, very poor, and it is obvious that the existing postal charges are simply prohibitive to them. The expensive stamp is purchased more and more rarely, then an unusually long interval of silence elapses, and the parted friends feel a kind of shame which hinders them from writing at all; and gradually all thought of or interest in the land and friends left behind fades from the wanderer's mind. How sad all this is. I speak not only of the delight denied by ruthless and mistaken economists to men who, by expatriating themselves, render a real service to the empire in this stage of its development, but also of the foolish repression of a natural instinct, which should be encouraged for the benefit of the State.

These heavy charges, so injurious to Imperial and commercial interests, are quite unnecessary, and they even injure the revenue—as excessive taxation always does. Bruce, the traveller, tells us—I hope untruly—that in his day a hungry and thoughtless Abyssinian would cut a steak from one of his living oxen. No wonder if the poor animal sometimes languished and died of the wound. It can be shown that a letter can be carried to the Antipodes at a profit for one penny, and Sir R. Hill declared that a farthing per letter would amply remunerate the shipowner. Why, then, should such a charge as 6d. be imposed? Surely if it pays to convey a letter by the expensive railway route from New York to San Francisco, 3,000 miles, for a penny, it should be possible to send one by sea from Liverpool to New York, also 3,000 miles, for a penny. For the carriage of the most valuable goods by sea is only about 40s. per ton, while the Post-office charges for letters rates running up to £1,972 per ton. How is this difference to be explained? How is it, to take a single fact, by way of illustration, that the Post-office finds it profitable to send a copy of the *Times* newspaper, weighing 4 ounces, to Australia for a penny, and exacts 4s. for a letter of the same weight (4 ounces) sent in the same steamer to Australia?

The answer is, that our Government having, as we have seen, an immense amount of commerce to protect, is compelled to subsidise several great steamship lines, on condition that these lines shall maintain a fleet of ocean-going clippers, available as cruisers and troopships in the time of war. The subsidies now amount to £641,000 per annum, and as they are charged to the Post-office, that department raises the amount by means of the heavy rates for outward carriage of which we complain. It recalls the story of the Arab's dog which, having been beaten by its master, and being afraid to retaliate on him, went out and bit a child. So the innocent British emigrant, merchant, or merchant's workman, has to defray the cost of maintaining these reserve warships, because that cost has been wrongfully imposed on the Post-office. Surely the cost of keeping up our naval strength is a national affair and ought to be defrayed by the taxpayers generally. Formerly, indeed, it was so defrayed.

Up to 1858, the subsidy for the Indian packet service was properly charged to the Admiralty, the mail steamers being regarded as an auxiliary naval power. For some reason, however, this was entirely altered, and on the Post-office was placed the whole burden, although the following protest was made:—"The claim that the Post-office should be charged with the whole expense of this packet or ocean service must be considered as barred by the simple fact that few of the mail packets were established either by the Post-office or for merely postal purposes." To assume that these packets were really established for Post-office purposes is to charge the Government with the most absurd extravagance. The West India packets, for instance, were established at a cost of £250,000 per annum, though the utmost return that was expected from letters was £40,000, leaving the £200,000 a clear deficit (Post-office Report, 1863). Subsequently a Select Committee of the House of Commons recommended that "a fair proportion of the expense should be charged to the Admiralty, and that the Post-office should be charged for the actual transmission of mails." This recommendation has been ignored.

When the last contract with the Peninsular and Oriental Company was made, a saving of £107,000 a year was effected, mainly in consequence of my remonstrances. This amount of course goes to swell the Post-office surplus.

Every branch of the foreign and colonial postal service is profitable, except those to India and the East, and to the West Indies, on which there is an enormous deficit, amounting to more than £200,000 per annum for India alone. India is a kind of Crown colony held by us for the sake of its valuable trade; it is held, in fact, for the benefit of the British nation as a whole, and it is grossly unjust to make the writers of, say, Australian and Canadian correspondence pay the Indian deficit in the shape of heavy postage rates. It would be just as logical to charge the £200,000 on Irish correspondence. But amidst the numerous anomalies with which the postal system fairly bristles, this particular injustice is apt to be passed by as "a very little one."

The German Government has kindly offered to convey British letters to India (our own colony) in German ships at about half the rates for postage which we now pay. The Postmaster-General refused to let the writers of letters to India be relieved this way; but what a humiliation for the Mistress of the Seas lay in the offer of the blunt Teuton! I was the medium of that proposal, and I am prepared to get the Germans to give us a mail service to Bombay and China for half the money now paid by us. Moreover, the establishment of a national line of mail steamers from England to Shanghai and Japan, with branches of fast mail-boat services from Aden to Bombay, and from Colombo to Australia, would provide a better mail service, at a saving of £100,000 a year. Nay, I would, for the sum now provided for mail subsidies, undertake to telegraph the contents of the letters gratis.

The Secretary to the Post-office laments that the postal business is "not conducted on commercial principles." You will hardly be surprised at his artless admission after hearing the facts which I have already stated. Let me add that the accounts of the Post-office are in such a fashion that no man can understand them without instruction, any more than he can thread the catacombs without a guide.

By accident I discovered that the revenue of the Post-office was £700,000 more than is represented in the Estimates. I called for an explanation of this, and the following extraordinary statement has been officially given me:—First, that if a person puts a sixpenny stamp on a letter to Australia and a fivepenny stamp on a letter to India, Parliament is informed that the revenue received was 8d., and not 11d. The postal authorities, without consulting Parliament at all, pay away the 3d. unaccounted for to foreign Governments, and make contract with foreign Governments and railway companies for conveyance of mails to the extent of £300,000 a year, and these contracts are never submitted to the House of Commons; but for the conveyance of mails throughout the United Kingdom, and to the Continent, America, and the Colonies, the accounts are submitted to Parliament.

Again, the extraordinary method is pursued of paying out of the current revenue of the Post-office the cost of land and buildings required for Post-office purposes, and through this means the Postmaster-General owns already land to the value of more than £2,250,000 in London alone. No business man in the world would conduct his affairs in this manner—taking no account of the money he expends in landed property and buildings. Yet this very department, that trifles with hundreds of thousands of pounds, refuses to allow a local postmaster in my constituency to expend 1s. 6d. in mending a lock of a door, but insists on dispatching an officer from the Office of Works to the scene at a cost of £3 10s. This I proved before the Select Committee.

There is a kind of "Spenlow and Jorkins" arrangement between the Post-office and the Treasury. It took me three years to get the parcel-post extended to France, and it involved scores of questions to the postal authorities, scores of letters to the *Times*, visits to France, public and private interviews, constant bickerings; France declaring that England blocked the way, and England declaring that France blocked the way; refusals in Parliament to produce the correspondence, and —victory. A similar story might be told of the De la Rue contract. To look up the earlier questions and replies given me when we were assured that the contract was a boon to England, and the "climbing down" replies a year afterwards, when it was coolly acknowledged that we were losing £60,000 to £70,000 a year on this Post-office stationery arrangement, one finds it difficult to believe in any answer given by a Minister. It took us two years and three months to introduce the system of telegraph money orders. You will notice by "Hansard" that it was on the night and early morning of June 6 and 7, 1887, that I kept Mr. Raikes from getting his Post-office estimates until he promised "to comply with the suggestions of the hon. member for Canterbury, and introduce, as an experiment, the Post-office telegraph money-order system." Well, only on the 2nd of September of last year the promise has been fulfilled. Again, it is worth while to notice the trouble Mr. Raikes himself had to remedy what he called "a grave Post-office scandal." I have before me the first letter I wrote to the *Times* on the subject, pointing out that millions of samples of English merchandise were being sent from London to be posted in Belgium back to every town in England at half the rates that would be charged in England, for it was far cheaper to post a parcel on the Continent for Canterbury, or Manchester, or Glasgow, than from London to these places. Incredible as it may appear, the Postmaster-General's threats and pleadings for this reform were ignored for years by other members of the Government.

I have now said enough, I think, to show that there is urgent need for reform in many departments of postal business—although I refrain from dilating on such grievances as the refusal of the Post-office to sell inland post-cards at their face value (as is done in every other country in Europe), its suppression of privately printed post-cards, its objection to the affixing of stamps on post-cards, its charge for re-addressed letters, its prohibition of the continental plan of sending circulars out in unclosed envelopes, &c. Most of these are "poor man's" grievances, and are none the less entitled to the fullest and readiest consideration. But with respect to the last, I may mention that India is flooded every week with French circulars, soliciting orders, &c., conveyed by the British Post-office for one half-penny. British Indian merchants can save large sums by posting home from Goa or Pondicherry, just as now one firm alone saves more than £1,400 a year by posting its foreign and colonial letters in France. These things touch the Englishman's patience at a tender spot; he will endure much from a paternal Government, but he will not submit to unfair taxation.

My scheme of ocean penny postage is explained by its title. I propose to convey a letter, weighing half an ounce or less, from any place in the British Empire to any other place in it, or to the United States for one penny. And I assert that the revenue will be largely benefited by the change. At present, as I wish to establish my facts before doing anything, I am asking Parliament to grant a Select Committee to iuvestigate and report upon them; and this, as the *Times* remarks, can hardly be refused. Before that committee I am prepared to prove all that I have stated to-night, and much more. I will show that the average cost of conveying the letters could not exceed one-eighth of a penny; that it is cheaper to send a letter to-day from London to Australia than it was fifty years ago to send one from London to Edinburgh, and that it costs less to convey a letter from London to New York to-day than it did cost to send one from London to Dublin in 1840.

I do not propose to interfere with the present plan of sending Indian and Australian letters overland, *viâ* Brindisi, to be picked up by the mail steamer in the Adriatic. By this route a day or two is saved, and probably the more important class of business letters would still be sent by that route, at the 2½d. in place of 5d. and 6d. rate, though where urgency exists merchants would of course telegraph. But for the larger class of business letters of secondary importance, family correspondence, and so on, I would provide a regular all-sea service of swift liners, starting from Southampton at the penny rate. I may here mention that these steamers often now do the journey to Australia as quickly as provided by the contract *viâ* Brindisi. The freight by a first-class steamer for valuable goods is about £2 per ton. I would propose to pay for letters £100 per ton, which would give the shipowner a magnificent profit. At a penny per letter the postage of a ton of letters amounts to £298 odd, so that there would be profit for the Post-office of nearly £200 a ton, amply sufficient to cover the cost of distribution, &c. I estimate that, taking the lowest possible amount of correspondence, the utmost possible degree of friction in the agencies employed, and the unnecessarily great expenditure of the Post-office, the scheme advocated would involve the additional outlay of about £60,000 per annum for the first year or two. If this calculation, says one critic, be right "within a qunrter of a million or so," the reform is sure to be granted. I maintain that it is a liberal estimate.

The Select Committee or Royal Commission would have before them a map of the British Empire and of America, and the lines of communication. It would be pointed out that penny postage exists throughout Great Britain and Ireland; it exists throughout the great American continent; that halfpenny postage exists throughout the great Empire of India; that penny postage exists to a great extent in Australia, and in five years or less will be general throughout that continent; that penny postage exists in the Cape of Good Hope and Natal, and it is believed will be soon general throughout British Africa; and that for the insignificant expenditure of £60,000 a year more than at present provided, the links might be added, and ocean penny postage would be possible between all these countries. Not an extra train, steamship, or postman would have to be provided to carry out this reform, for the requisite machinery is now in full operation.

On former occasions it has been objected that the Colonies are unwilling to lead the way in this matter. Of course they are. The colonial post-offices are generally unremunerative, for the distances are great, and the means of communication few and imperfect. It is the duty of the British Post-office, with its big surplus of nearly £4,000,000, to lead the way, and we may be sure that the Colonies will follow like ducklings diving after the parent bird. Under the Postal Union, England benefits largely, while, as we have seen, the Colonies suffer. If proof be needed of this, I will cite the Postmaster-General's own testimony before the Select Committee, from which it appears that the quantity of correspondence and other matter posted here and despatched from the United Kingdom largely exceeds the quantity received; and I will prove that the British Post-office benefits to the extent of £228,000, or more.

It should be observed that the revenue would not be affected if the writers would simply spend as much in postage as they now spend. Thus, if each of the writers to and from Australia, using the ocean penny post, would write six letters in two years, instead of, as at present, one in two years, and if each of the writers to and from the United States would write five letters for every two now written by him, and so on, the same revenue would be produced as is now received. For the steamer owners contract, or will contract, to carry any additional bulk of letters without extra charge, so long as the present revenue is guaranteed them, and surely the writers in question might be trusted to do so much.

The income of the Post-office from English and Australian correspondence is increasing at the rate of £10,000 a year, and the correspondence between England and America at the rate of £20,000 a year, even under the pressure of the present rates.

The growth of correspondence between England, India, the Colonies, and America has been enormous during the past ten years. No less than 1,200 bags of mails were put on board the *Britannia* for India and Australia in one week, as against 700 bags ten years ago. The mail for India ten years ago, I am informed, averaged 250 bags, to-day the average is over 400 bags weekly. But, incredible as it may appear, the official statements show that the Australian receipts for postage have increased nearly 50 per cent. in ten years. The American mail service with England also shows an extraordinary increase and a profit of at least £100,000 per annum. Yet Mr. Raikes recently spoke of the Colonies and the United States as an "area of unproductiveness" (whatever that may mean).

As bearing upon this question, let us take the analogous case of the great reduction of postage in 1839. In that year there were carried or delivered in the United Kingdom, in all, 82,500,000 letters. In 1840, the first year of penny postage, there were delivered 169,000,000, and last year the total reached 1,558,000,000. Mr. Raikes's reference, at the Jubilee banquet, to the "area of unproductiveness" was skilfully illustrated, but it was merely the art of the special pleader. To show that my scheme would not pay, he pointed to India, with some 200,000 Europeans. He chose, in fact, the service on which the huge deficit of £224,000 has occurred. But that deficit is caused by the lavish subsidies bestowed on the Peninsula and Oriental and other mail lines; and if a private company were permitted by law to do the work, the 200,000 Europeans might have their letters conveyed at once for a penny each at a profit. Why did he avoid any reference to the United States, with 60,000,000 of educated citizens; or to Australia, where the percentage of letters exchanged is the largest in the world? We have seen how the surplus population of the United Kingdom is continually pouring out into the world, every man instinct with Anglo-Saxon pluck, energy, and persistence, hewing his way through virgin forest, bridging fierce rushing rivers, planting, building, and working from dawn to dusk. Soon great cities rise in what was a wilderness, the hum of commerce is heard along busy wharves lining a shore where before all was solitude. And, high above all, floats the beloved flag which reminds the wanderer, whenever his eye rests upon it, of all that he has left behind—the scenes of childhood, the venerable tower, the well-remembered street, the faces of dear friends, and of some nearer and dearer still. We send out our ships, and trade with the settlers; their wants find employment for millions of our workers at home; their lands become a part of our Imperial heritage; in a word, we reap much of their labour. They ask but one little token of brotherly kindness of us in return — that we will be content with a moderate profit only on the transmission of the letters from home, which are so unspeakably precious to them. This boon the people of the old country would give, but the Postmaster-General stands in the way. From this little island of ours, the very heart of civilisation, pulses forth the vital stream that circulates to the very ends of the earth. In vain will a presumptious official bind his petty tourniquets on the gigantic limbs of the Empire, and mincingly profess that they are cold. He might as well try to turn back the Amazon in its bed, as to hinder the flow of that mighty tide.

Let me here mention an incident of a touching character which illustrates what I have said. Not long since an M.P., while in a village post-office in Lincolnshire, heard a poor old woman asking the cost of posting to her son in Australia a letter which she held in her hand. "Sixpence," said the postmaster. It appeared that she had not so much. She could pay a penny, she said, and that would leave her something to buy bread with, and so she tottered off ready to cry. My friend could not stand this. He hastened after her, took the letter, and paid the postage. Three months afterwards (at Christmas time) the postmaster accosted him, smiling, and informed him that in answer to the letter thus charitably paid for, the old woman's son had sent her £5.

I have dwelt sufficiently on the advantages to the Empire and to our foreign and colonial trade, which would accrue from the establishment of ocean penny postage. I may add that I have acquired the settled conviction, in the course of an extended Eastern tour during the past recess, that no gift on the part of the mother country would be more gratefully and even enthusiastically welcomed by the Colonies than this which I have suggested. The Press of the English-speaking world calls with one voice for a reform sanctioned by the authority of Sir Rowland Hill himself, and rendered still more urgent since his day by the astounding growth of our Empire and our commerce. I have in my possession thousands of extracts from English, American, Indian, and Australian journals testifying to the wide and warm interest aroused in the matter. The question is now ripe for solution, and the favourable decision of Parliament cannot be long delayed, in the face of the remarkable and general manifestation of public favour which ocean penny postage has quite recently evoked. As your Chairman remarked here last week, the Post-office has, since Rowland Hill's time, been stagnant from want of competition. That remark leads me to make this deliberate assertion, that when ocean penny postage, say to Australia, is inaugurated, the racing clippers of the popular penny service will, nine times out of ten, reach the Island Continent in a shorter period than is now allowed by contract on the Brindisi route. One more observation. Mr. Goschen is unwilling to touch the Post-office surplus for this purpose. I am content. That surplus amounts to nearly £4,000,000. But it grows at the rate of from £200,000 to £350,000 per annum. Next year let him take last year's postal profit again, and let the cost of ocean penny postage be defrayed from the expected accretion of £350,000.

TELEGRAPHS.

I now pass to a subject which is even now of striking importance, and which is fated to become more important with every addition to the grandeur, the wealth, and the power of the Empire, namely—the question of cheapening and facilitating telegraphic intercommunication among the scattered dominions of the Queen. I have been reproved by a friendly monitor for pursuing postal reform too exclusively, to the neglect of the still more pressing problem of the cable-rates. Now there is an excellent French proverb which runs thus:—"Qui trop embrasse, mal ètreint." I prefer to break my bundle of sticks one by one. But it must not be supposed that I no longer recognise the growing urgency of those reforms in the telegraphic service which I have for some years advocated. Already the telegraph is rapidly supplanting the mail. Within each national area—the area of the United Kingdom, of France, of Germany, of America, of Canada, of Australia, and so on—the telegraph is now used more frequently than the mail was when we were young. The number of telegraph messages now sent annually in the United Kingdom exceeds the number of letters carried by the mail coaches fifty years ago. The case of international communication is entirely different. A marvellous invention, whereby the natural obstacles of space and time are annihilated, has been selfishly appropriated by a set of long-headed monopolists, and 999 out of every thousand men are as absolutely debarred from the use of it as if such men as Franklin and Wheatstone had never existed. The cable system between England, India, South Africa, the East, Australia, and New Zealand exists for the benefit of the Eastern Telegraph Company, and not for the good of the public. The Company's line run only to India, but practically it is identical with the Eastern Extension Company, whose lines run to Australia, the Straits Settlements, China and Japan, and with the Eastern and South African Company, with lines running to Zanzibar and the Cape. Sir John Pender has so distributed it that it is difficult to oust him from his position of supremacy. It is not only that his companies have the only line to Australia, but he has made it almost impossible for any other line to be laid with a prospect of profit. Thus lines might be constructed from Australia to the Straits, Ceylon, or the Cape, but every one of these would simply merge in and feed the Eastern Company's systems. This world-embracing monopoly levies dues in a correspondingly grand scale. We must pay for a telegram to the Cape 8s. 11d. per word, to Australia 9s. 4d., and to New Zealand 10s. 6d., while to some points the charges are 27s. per word. As a consequence, the shares of the companies concerned are quoted at from 15 to 40 per cent. premium respectively, and these companies, afraid to declare too large dividends, have an enormous reserve fund and an enormous store of surplus cable. By way of showing how large are the sums expended in sending cable messages, I may mention that one message from Australia to England cost £1,400, another message cost £1,200; a short message of 58 words cost me £30, and it is no uncommon occurrence for a member of the Australian Government, or an Australian merchant, to send a message at a cost of £100 to £200. Last year no less than £360,000 was expended in cable messages to and from Australia, the expenditure being thus at the rate of £1,000 per day. Taking the price paid for messages in 1885, viz., £308,000 for 47,000 messages, we find that the average price of every cable message to Australia exceeded £61. And this is the way we encourage federation!

Colonists in England frequently and loudly complain of the meagre character of the telegraphic intelligence sent to England regarding Australian affairs, and appearing in the English press. We must admit that they have reason to complain, if we remember the magnitude of their business transactions, how many thousands of Australians reside in this country, and how many thousands of Englishmen maintain business relations with Australia. £20,000 at least is expended by the Australian newspaper proprietors in wire and other charges for present telegrams from England to Australia. On the other hand, I do not believe that £250 is expended on telegrams from Australia to England by the English press. Those long and interesting telegrams which you see every day during the sittings of the Congress in Melbourne are paid for by the Australian Government.
regards international intercourse, one of the

The result of this state of things is that, as
mind is brought to nought. For all the
most beneficent discoveries of the human
ordinary every-day operations of trade, and
for every kind of social intercourse between the nations divided by water, telegraphy practically does not exist. It is sparingly employed for the purposes of Government, and still more sparingly by a few wealthy firms; but the several peoples remain isolated, each from the outer world, from mail day to mail day, like blind and deaf mutes, sitting in stony silence in the family circle.

Now, if the conception of Imperial unity—of a brotherhood of British nations—is ever to be realised, this monopoly must first be broken down. One proposal for this purpose, which was considered at the last Colonial Conference, was to lay a cable from Australia, *viâ* Fiji, to Vancouver, the Pacific terminus of the Canadian Pacific Railway, and there connect it with the line through Canada, and across the Atlantic to Valencia. In a paper which I read before the Royal Colonial Institute two years ago, I described this route in detail, and showed that it would extend over 8,900 miles, while the cost would be £2,000,000. I proposed also to acquire the Eastern Extension Company's cable for a sum of £2,200,000. The two undertakings would thus cost £4,200,000. The purchase of the Eastern Extension Company's lines would extinguish subsidies now paid by the Colonies to the amount of £56,700 a year; and the net result, I proved, was that the total annual charge for the acquisition of complete Governmental control over the Asiatic and Pacific telegraph routes would be £65,900. Of course, the first result of these operations would be an immediate reduction of rates. Telegrams could even now be profitably sent between England and Australia for 1s. per word. With reduced rates, Sir John Pender thinks the Imperial telegraphs, taken as a whole, would yield a profit of a million a year. Take the Pacific cable. It could transmit annually 10,000,000 words. That would mean a return of £500,000 a year. I calculated this on the duplicate system of cabling, but by a new invention four messages can be transmitted each way at the same time along a single cable. The centre of the existing cable system of the world is undoubtedly London. As all roads led to Rome, so do all the great ocean telegraph routes lead to London. From a space measurable by yards within the capital of the Empire there radiate actual, material, tangible lines of communication reaching to Vancouver on the one hand and to Wellington on the other. A glance at the map on the wall will show the system in detail. There are, first, the great western route to the United States and Canada; secondly, the great eastern and south-eastern route to the Mediterranean, India, Australia, China, and Japan; and thirdly, the great southern route to South America and the West Coast of Africa. The first idea that occurs to me is, that the governing thought in this system has been to link together, like so many pearls on a single string, the scattered dependencies of the British Crown; and the fact unquestionably is, that the cable system of the world serves this purpose. The cable net is the nervous systems of the Imperial organisation. Sometimes, when I muse on these things, a striking prospect of the future rises before me. I see the larger and fairer half of the world, including scores of dominions, principalities, colonies, and settlements, united and happy under one British Sovereign, throbbing with the same aspirations, suffering the same anxieties, discussing a common policy as if face to face in a room, exchanging instantaneously advice, condolence, or congratulation. I see the emigrant in New York flashing words of love, and with them the money that is needed, to a sick mother in some poor Irish cabin. I note the keen-faced merchants discussing their elaborate daily reports of the state of trade in regions thousands of miles away; I hear politicians in London debating with minute and full information the problems that stir and agitate the Antipodes. But such a vision to be realised requires that the Government of Imperial England should perceive its obligation to control and administer those great material agencies on which so much of our happiness now depends. It is interesting to note, while on this subject, that the American Postmaster-General proposes to acquire the telegraphs of the Union for the State. It is announced that the British inland telegraphic service now yields a profit even on the sixpenny messages, and we may be sure that Mr. Wannemaker's venture will be equally fortunate.

I wish now, if I have not already exhausted your patience, to submit to you a scheme for constructing either one or two additional lines of telegraph between Europe and our great Indian dependency. This scheme originated with a friend of mine, a public servant of much merit and distinction, Mr. Charles Pitman, C.I.E., Superintendent of Government Telegraphs in the Bombay division, and to him I am indebted for the details of a plan which, in my humble opinion, well deserves the attention of the Government and the mercantile class. Mr. Pitman was the officer in charge of the telegraph operations in Beloochistan and Southern Afghanistan in 1876-9, and his testimony on any question connected with the construction of telegraph lines in that wild country may be regarded as by far the best obtainable. He thinks that one line, or two lines, might be easily and rapidly constructed (of course, by the State) which would complete the telegraphic land communication between England and India, and yield a handsome profit on the outlay.

The advantages of the proposed line, or lines, are obvious enough. In the first place, it would be possible to reduce largely the present heavy charge of 4s. per word for messages to India. Mr. Pitman thinks that the rate might fairly be put at 1s. a word, but in my opinion a still lower figure might be adopted. What a stimulus such a reduction would give to Indian trade can be easily imagined by those conversant with the commercial aspect of the question. But I may remind my hearers that the United Kingdom takes 55 per cent of the total trade of India, and that our exports to that country increase to the extent of millions of pounds every year.

Another great advantage would consist in the prolongation of the Indian telegraphic lines up to the Russian Asiatic frontier, so that full and early warning would be ensured of the first movement of the Komaroffs and Alikhanoffs towards Herat. This is a question entirely for our military friends, but I believe there are few of them who do not endorse Mr. Pitman's views in the matter.

There are at present four available telegraphic routes to India, namely, (1) the Eastern Telegraph Company's cable, down the Red Sea and on to Bombay; (2) a line *viâ* Tiflis and Teheran to Bushire, and thence by the Indian cable to Kurrachee; (3) a line from Constantinople through Bagdad to Fao, at the mouth of the Persian Gulf, and thence by cable to Bushire and Kurrachee; and (4) a costly line through Siberia to Vladivostock, and thence by cable to India. These may be shortly described as the Suez, Teheran, Bagdad, and Vladivostock routes. The Bagdad line is so defective, and the Vladivostock one so long and expensive, that they are rarely used, and India is practically served by the Suez and Teheran routes only. Now these two, although well manned and worked, have two drawbacks. They are dear, and submerged sections involve considerable expenditure for repairs, and sometimes both the Suez and Teheran routes are simultaneously interrupted for a considerable period. It is therefore clearly better to have a land line, if possible, from across the English Channel to Calcutta and Bombay.

Several alternative routes have been proposed. The two preferred by Mr. Pitman are (1) "an overland line of telegraph through Southern Afghanistan, to join the Indian system terminating at Chaman, and the Russian system, which has been extended to a point near Penjdeh," and (2) "the construction of a first class line of telegraph from Fao to Constantinople, the lines from the former place to Kurrachee being multiplied." These may be shortly described as the Afghan and the Turkish routes. He is strongly prepossessed in favour of the Afghan line; but without venturing to question the superior value of his judgment, I would point out that this route would also pass over Russian soil, and would therefore be exposed to interruption in time of war; but he truly says that we are not at war with Russia for more than two years in a century, and it is certain that, in case of war, commercial operations would to a great extent necessarily cease, and therefore my observation may be taken for what it is worth.

With regard to the Turkish route (Bushire-Fao-Bagdad-Constantinople), there are no physical difficulties in the way, and the wire would be carried through the dominions of our gallant and faithful ally the Sultan. I feel bound to express my earnest hope that, in any case, this route may be one day utilised, even though I believe that the Afghan route will be the one immediately selected. Land telegraphs are cheaply laid where there are no obstacles to be overcome, and one would like to see the rich and intelligent communities of India provided with every possible facility for intercourse with Europe.

Well, my friend's pet project is the Afghan overland route, and that I will indicate in some detail. The Indian lines end at Chaman, on the Afghan side of the Khojate Amran range. From Chaman to Candahar is a distance of some seventy miles, from Candahar to Herat it is 375 miles, and from Herat to Saraks, or Meshed, about 200 miles. Mr. Pitman proposes to make Herat a junction station, from which one wire would branch off to Penjdeh, and there feed the Russian system, along the Transcaspian railway to Europe; while another would be carried to Kuhsan, on the Afghan-Persian frontier, and thence to Meshed and Teheran, where the existing trunk line beween India and Europe would be joined.

As regards the work of construction, it appears that up to Herat there are no difficulties worth mentioning to be surmounted, and the wire could be rapidly set up. There are railways, it will be remembered, on the one side to Quetta, and on the other to Merv, and thus hollow iron posts could easily be conveyed to the district, and then be transported to their sites by the local camel service. The cost would be moderate. The maintenance of the posts and wire intact ought not to be a troublesome matter. Part of the route traversed lies through a thinly-populated country, the inhabitants of which are not likely to interfere with the line. In the Candahar-Farah district the turbulent tribesmen might overthrow a few posts at first. But the Ameer is so greatly feared as a stern, inexorable vengeance taker, that when once the fact of his protection of the line is thoroughly grasped, there will be no fear of mischief. His highness is our subsidised ally, and is personally interested in electrical art, and it is believed that he would readily agree to the making of the line, especially when it was pointed out to him that by its means news of a Russian advance could reach Calcutta in an hour or two. A few years ago, the telegraph actually reached Candahar, and during the military operations of 1879, it was guarded by Afghans in our pay. It is clear that if we could maintain the line in working order while we were invading the country, we could do so now that we are at peace with and actively supporting the Afghan ruler. Doubtless the Indian Government, if it undertook the work, would provide a staff of Sunni Mahomedans, so that no fanaticism should be aroused, and would employ the local tribesmen in protecting the posts. It is interesting to remember that, during the war, the wool-traders of Candahar, and the horse-dealers of the Pishin Valley, made considerable use of the wire for the transaction of business. It is useless to regret the too hasty pulling down of the posts and wire, by order of the British authorities, at the conclusion of hostilities, but it is not to late to repair that blunder; and I need not point out to this audience that the next Ameer —if we delay the matter until his time—may not be so friendly to us as the reigning one is.

It is true that, not long since, the life of an unprotected European was not safe in Afghanistan, but those days are past. Only a few years ago the Boundary Commission was most cordially welcomed, and since then two

Europeans, Captain Griesbach and Mr. Pyne have been employed in the Ameer's service at the capital, Cabul.

This scheme, I may add, has the support of Lieut.-General Sir Andrew Clarke, R.E., who, writing to Mr. Pitman, uses these words:—"You will see from the enclosed that I agree with you, and that I advocated the line as far back as 1876."

It will be observed that any extension, such as I have outlined, of Indian telegraph facilities could not fail to be of immense benefit to the great Australian Colonies, as well as to important trading centres in the far east, like Singapore, Hong Kong, and the Chinese treaty ports. I will confess that this consideration had considerable weight with me while listening to Mr. Pitman's exposition of his plan, and I believe that the modest supplement of an additional cable from Madras or Ceylon, or *viâ* Burmah, down the Straits of Malacca to Singapore, and thence to the nearest point on the southern continent of Australia, would by no means detract from the usefulness of the scheme. However that may be, I feel sure that my hearers will agree with me in the substance of my argument, namely, that telegraphic communication between England and her colonial possessions should be made cheaper, easier, and more secure; and that reform lies in the direction of the acquisition or construction by the State, on behalf of the whole empire, of a sufficient network of sea and land lines.

I have now laid before you a brief sketch of the measures which, in my humble judgment, should be adopted for the improvement of the postal and telegraphic service to and from the Colonies and India. In all the postal changes I advocate you will perceive the logical development of the grand but simple principles of Sir Rowland Hill. I only ask that the Post-office, inspired with the consciousness of its high mission, and with the memory of its former splendid services, shall strive to win fresh laurels in new fields. It is a critical moment in the history of the Empire; envious hands are stretched forth to grasp our inheritance; every nerve must be strained to maintain and safeguard our position. It is in the power of a great public department, with glorious traditions and inexhaustible resources, to come to the aid of those who are closely pressed in the struggle, to relieve the strain on their strength, and to turn the tide of battle in their favour. How long must we wait before the order is given to advance?

DISCUSSION.

Mr. Hyde Clarke said Mr. Heaton needed no apology for bringing this subject before the Society, which, in the days when there was no London Chamber of Commerce, had a Postal Committee, and did its best to urge on postal reform. On one occasion, as chairman of that Postal Committee, he had the honour of waiting on the Postmaster-General, as Mr. Heaton had done more recently, and the proceedings were very similar in each case. On behalf of the mercantile community, an application was made to reduce the rate on foreign circulars and printed matter from 1d. to ½d. The Postmaster-General said it was totally impossible, they could not be carried under 1d. The answer, with which he was already provided, was that they were carried for ½d. by the Belgian Government, and the consequence was that a great deal of English printing went to Belgium and was posted there. The Postmaster-General therefore somewhat modified his tone, took time to consider, and ultimately the ½d. postage for circulars was introduced. This must be an encouragement to Mr. Heaton to persevere in the course he had begun. He was very glad to hear his reference to the English-speaking part of the world, a phrase which had been introduced by Mr. Russell Lowell and himself, and adopted by statesmen and the public to express a great political and racial fact; and it was a matter of great importance to keep up communication amongst the English-speaking race. The high rate of postage to Australia tended greatly to limit correspondence, while, on the other hand, it had been mainly through the cheap postage of letters and newspapers that such a cordial feeling of sympathy had sprung up between England and the inhabitants of the United States, a feeling which he believed was now proof against the unworthy attempts of agitators. There was now one common pulse throughout the English-speaking world, and when a President of the United States was stricken down, and lay on his death-bed, every detail of his illness was printed in English newspapers, and anxiously read by thousands throughout the world. Wherever an English newspaper penetrated, or where one was established, either by an Englishman or an American, it tended to promote a strong feeling of sympathy between all the members of the great family. They might also look forward to a great increase in the number of English-speaking people. The Government of India had lately dared to allow the people to learn English, and there must be already some ten million natives who spoke it, and that number would soon be largely increased. If, however, they wanted to reach them, and communicate with them, the rate of postage must be very much reduced, for the rate of wages there was only 3d. or 4d. a day. The chief difficulty, no doubt, was with the Treasury, but he thought it a very good suggestion that the tribute levied on the Post-office by the Treasury should be fixed. One result of that would probably be that the Post-office would be emancipated from that old man of the sea, and would be able to look after its own departmental concerns, instead of having to refer to the Treasury for the payment of every few shillings, and to wait for months before the desired work could be carried out.

Mr. ROBERT MANUEL thought there could hardly be anyone in the room who did not heartily concur in the views put forward by Mr. Heaton; but he was rather surprised to hear him say he should be content with the Post-office being administered on the principle of making four millions profit every year, and handing it over to the national exchequer. Of course, the Post-office should be worked so as to leave an ample margin against any risk of loss, but he could not agree that anything like such a margin as that was either necessary or economically sound. If a margin of one million were allowed, it would be more than ample, and any excess of revenue above that ought to go to decrease postal charges, or to increase facilities for sending telegrams, parcels, and other things. Mr. Heaton's proposal was a very modest one, and it was almost incredible that so great a reform could be carried out at so small a pecuniary sacrifice. This was an instance of the great danger there always was of want of elasticity when a great business was managed by a Government department. At first there was great energy, and great improvement, but after a certain stage was reached, a fossilising process set in, and now the English Post-office, which was at first the pioneer, sadly lagged behind. He would ask if the figures which Mr. Heaton had mentioned for buying up the Eastern Telegraph Companies were based on the actual cost, or how did he think he was going to induce the owners to part with their property to the Government except at a prohibitive price. He remembered when the ordinary telegraphs were purchased, the shareholders reaped an enormous harvest, because directly it was known what was going to happen the shares went up about 100 per cent., and he feared the same thing would happen again, unless Mr. Heaton had some plan for preventing it. The importance of postal and telegraph reform to the whole Empire was too obvious to require remark. He remembered when the only newspaper of any note in London was the *Times*, and the great mass of the people were as little informed about French and German politics as they now were with regard to the local politics of our vast Empire abroad; but with the introduction of penny papers, and the enterprise of their proprietors, we had all become more or less familiar with the politics of Europe; and if there were the same facilities, we should become increasingly informed as to the doings of our countrymen on the other side of the world, to the great advantage of the Empire and our own instruction.

Mr. W. LASCELLES-SCOTT said there was no subject on which the Society could more usefully exercise its influence than the one now brought forward. He was astonished at the modesty of Mr. Heaton's proposal, and though he did not think any Treasury or Ministry would ever consent to disgorge three-fourths of the present four millions which they now received from the Post-office, because it would mean adding something to the income tax, which again would be likely to mean the loss of office, still it was high time that some limit should be placed on the rapacious maw of the Treasury in this respect. The commerce, industry, and education of this country and its colonies are held back by two things—firstly, by the high rates for ocean postage, and secondly, by the want of a cheaper newspaper rate, so that intelligence might be more widely diffused. The limit of the halfpenny postage had now been about reached, and there ought to be a farthing inland postage for newspapers.

Miss WEBSTER suggested that it would be wiser to agitate at first for a uniform foreign rate of 2d. or 2½d. If a 1d. postage were adopted, it would probably open the door to a great agitation for reducing the inland postage to ½d., and it was very doubtful if that would pay.

Captain FAIRHOLME said he had been living for some time half in England and half in Berlin, and had had experience of an enlightened Post-office in one country, and quite the reverse in the other. This subject was not understood by people in England, but if they would examine the Belgian or German Postal Guide, and compare it with the English, they would see what an immense difference there was. This country was supposed to belong to the Postal Union, but in this country there was no such thing as Class B., which existed in every other, and which indicated a 2½d. postage all the world over. If a man in Australia had children in Europe, he could get a letter from one in Germany for 2½d., but from another in England it would cost 5d. or 6d. In Germany the Post-office system was far more convenient in every respect. Here you were not allowed to send drawings or anything under the book post regulations with a little flap turned in at the ends to prevent what was inside from falling out. Wrappers so made were sold largely, but any postmaster was empowered to charge them at letter rates. All this was the mere red tape of the permanent officials. Von Stephan, the German Postmaster-General, was a model. If you wanted a bill accepted, or an account collected, or to order an article and pay for it on delivery, you could do it all through the postman, without delay, difficulty, or routine. He knew a large firm in Germany which did all its business by means of money orders. You could also post letters at any railway station up to five minutes of the train leaving, and if you were not in time for that, you could go on to the platform and post the letter in the train as it started.

Mr. THOMAS CHRISTY said that on 'Change that day he had spoken to many persons about the meeting, who were all deeply interested in the subject, but found it impossible to attend. He held in his hand a small book of a scientific character, which was much sought after, because it told people how to turn to account many wild native products in Australasia; its cost was about 1s., but the postage was 8d., which was almost prohibitory; to India and China it would be 6d. To all these places there were steamers running, and books, papers, and documents could be taken and put on board in sacks, without any expense whatever, and landed in the same way; and, at cargo rates of £4 or £5 a ton, the cost would be very small indeed. But the Post-office had a monopoly, and would not allow the people in the City to collect these parcels and ship them like merchandise; they must go through the Government mill, and be taxed in this absurd way. The consequence was, that immense quantities of these books, price-currents, and papers were sent over in boxes and barrels to France or Belgium, and posted there, to go by slow steamers, and the Belgians and French got the greater part of the money. Why should not English people be allowed to make use of their own steamers, as French and Belgians were? One point worth mentioning was that the tea steamers coming home from China made the voyage faster than the Brindisi mail, and letters were often delivered four, five, or six days in advance of the Post-office, *via* Brindisi, for which an extra charge was made. A friend of his, who had just come from New Zealand, asked him why English newspapers should not be sent out there by the New Zealand steamers, and he held the New Zealand people would soon insist on some change being made.

The CHAIRMAN proposed a hearty vote of thanks to Mr. Heaton for the very admirable way in which he had brought forward this most important subject.

Mr. HENNIKER HEATON, in reply, said he was highly honoured by the very intelligent criticism and sympathy which his paper had received, and he was especially grateful to Mr. Manuel and Mr. Scott for the hints they had thrown out. With regard to Von Stephan, it might not be generally known that he was the originator of the post-cards which had been of so much service to the public. With regard to the Eastern telegraph cables, he could only say that the proposal he had referred to was made by Sir James Anderson at a meeting of another society on the same subject, and it was admitted on all sides to be fair, if he could get his shareholders to accept the present rate of profits as the ground for purchase. He would take this opportunity of thanking the Press of England for the kindly assistance they had always given him in pressing on this great reform.

ELEVENTH ORDINARY MEETING.

Wednesday, February 19th, 1890; SIR OWEN ROBERTS, M.A., F.S.A., in the chair.

The following candidates were proposed for election as members of the Society:—

Fellows, James I., Saxon-hall, Palace-court, Bayswater, W.
Gloag, Lieut.-General Archibald Robertson, 2, Mitre-court-buildings, Inner Temple, E.C.
Hart, Captain Herbert, Fairview, Stamford.
Jebb, George R., Birmingham Canal Navigations, Birmingham.
Radcliffe, Francis, 233, Burrage-road, Plumstead, Kent.
Tagg, Thomas George, Island Boat Building Works, East Molesey, Surrey.
Wing, William, 7, North Church-street, Sheffield.

The following candidates were balloted for and duly elected members of the Society:—

Morgan Frederick, 10, St. Edmund's-terrace, Regent's-park, N.W.
Morris, Phil. R., A.R.A., 33, St. John's-wood-road, N.W.
White, John Thomas, 11, Bedford-row, W.C.

The paper read was—

THE ORGANISATION OF SECONDARY AND TECHNICAL EDUCATION IN LONDON.

BY PROFESSOR SILVANUS P. THOMPSON, D.Sc., &c.

One of the most helpful methods of deciding on the best way of carrying out the solution of a difficult or intricate problem, especially where questions of policy, or interest, or class prejudice come into the case, is to consider those ways that are known not to be the best. A discussion of the ways in which Secondary and Technical Education ought not to be organised will clear the way towards a riper decision as to the way in which these branches of education ought to be organised.

Originality, individuality, and indomitable perseverance are three of the qualities which Britons carry with them all over the globe: they crop up in every undertaking—social, mercantile, political, or educational—at home as well as in the Colonies. Excellent as such qualities are, they entail a serious defect, namely, that their essential and inherent vigour, the very concentration of purpose which they connote, blinds in their possessor that sense of proportion, of sequence, of logical relation and co-ordination without which even the most earnest and devoted efforts must fail to secure the full measure of usefulness. Success in pushing forward a new movement implies indeed, almost of necessity, a certain contraction of vision, a certain narrowness of aim. Leadership in such movements usually falls to the enthusiast, the man of lofty but often contracted views, the man chosen not because of his knowledge of the world or of society, nor for his training in the work of organisation, but because he has the inborn capacity in him to devote himself to the one object that covers, to the exclusion of all other topics, his limited field of mental vision. Essentially useful as the enthusiast is in the progress of the world, his power arises out of the very limitations of his perception. All the more reason, then, there is that every movement aiming at the establishment of new institutions or organisations should be from time to time reviewed as it were from without; criticised not from the point of view of the well-meaning aims of its supporters but in relation to other existing institutions and organisations; discussed not simply as if it were the only fact in the universe but rather as a fact amongst a wider range of facts; discussed with a sense of proportion, with a perception of relation and co-ordination; discussed, in brief, logically and with knowledge, not irrationally or in ignorance.

To the present writer it has for some months seemed that the time was ripening for some such dispassionate review of the present movement in London for secondary and technical education. Fifteen years ago he enlisted amongst the enthusiasts in the cause of technical education, and, in the course of several successive years, wrote a number of articles and pamphlets upon various aspects of that question at home and abroad. For the last seven or eight years he has said little publicly on the question, having been closely occupied in the immediate work of carrying out technical instruction in one branch of that wide subject, and in administering the internal affairs of the City and Guilds of London Technical College at Finsbury. He speaks, therefore, with an actual experience, both as teacher and administrator, and not as a mere scribe. He would remark at the outset that he is solely and individually responsible for the views he set forth; that he sets them forth personally, not as an official of the City and Guilds Institute, and that they do not necessarily, in any way, express the views either of the benevolent founders of that Institute, or of the Council under whom he has the honour of serving.

Suppose that a system of secondary and technical education had to be created absolutely *de novo* to fulfil the needs of London; upon what lines should such a system be based? Given the existence of an organised system of primary education and of primary schools, an Educational Department of Government, available funds, and a more or less complete organisation for higher education of a literary and scientific order, is it not obvious to the most unintelligent that, in the natural order of things, a system of secondary schools should be co-ordinated, on the one hand, with the system of primary schools whence it draws its pupils, and on the other hand to the colleges for higher education to which, in turn, it will send them forward? To dislocate such a natural order by creating a separate bureau of secondary education, under a separate department of Government not in any immediate relation to the primary schools or to the higher colleges, is a profound absurdity. It would be a splendid example how not to organise a system. Technical education cannot, as a system, be divorced from secondary education of a non-technical kind; it is, indeed, only a part of secondary education, though distinct from the purely literary and purely scientific parts of secondary education in this, that whereas they are framed for the most part to lead onward to the work of the higher colleges, and so to the universities, the system of instruction in a technical school should not in all its branches necessarily aim at leading the pupil onward to the higher technical college, and thence to the Polytechnicum or Technical University. In other words, the technical part of secondary education, though necessarily more specialised than the literary or scientific part, is still a part of secondary education, and as such ought to be arranged to fit on to the system of primary education, the latter being properly organised to lead up to the former. To carry out the proper co-ordination in the various parts of the complete educational scheme, all ought to be under one general administrative department of Government, with a responsible head, but with a sufficiently elastic system of administration as to allow of local adaptations in the code of instruction. The management of the organisation for secondary and technical instruction should be in the hands of persons acquainted with educational methods and with the needs of local industries and each secondary or technical school should be under the administrative guidance of a head who, by whatever name he is called, should be a person of wide educational experience. The instructors of the technical classes should obviously be craftsmen accomplished in the technique of their respective subjects, and gifted with the power of teaching it and the principles that underlie it. The teaching must be live teaching, each pupil educating himself by working in the laboratory, or workshop, or studio under an instructor who has worked in his trade. Such teaching is worth more than all lectures by the most eloquent of lecturers, worth more than all books by the most encyclopædic of writers.

The buildings destined for secondary, and especially for technical, schools should be designed with special reference to the particular local industry, and fitted with appropriate laboratories, workshops, or studios, as the case may be. In particular, it should be remembered that in almost every branch of industrial work outside the chemical industries, the language in which directions are given to workmen is by means of working drawings drawn to scale; and that three-quarters of technical education is really drawing. Proper drawing offices, with light over every table, and room for each draughtsman to walk round his drawing, are a prime necessity. It is strange what ignorance prevails on this matter of buildings. I have been shown detailed plans for one of the new institutions in an outlying district of London, drawn up by some person who has been asked to specify the sizes of the rooms required, and does so by comparison with the rooms of the Regent-street Institution. Concerning this establishment, he states that it has "a large chemical laboratory." Now large is a relative term; but if the author of that report had taken the trouble to consult Mr. Robins's admirable book on "Buildings for Technical Schools and Colleges," his ideas might have been corrected. The fact is that the entire Regent-street Institution, of which its chemical laboratory is but a very small part, might be placed, gymnasium, swimming-bath, theatre, Pepper's Ghost and all, within the space provided for the chemical laboratory in the Polytechnic of Munich. The chemical laboratory of the Polytechnic of Zürich could comfortably contain not only the whole of the Regent-street establishment, and still be large enough to take in the whole of the technical schools at the People's Palace. The chemical laboratory of the Polytechnic of Berlin is larger than the whole building of the City of London College; and the building department of the Polytechnic at Berlin is considerably larger than the whole of the Birkbeck Institution. By the light of these facts, the proposal to provide a polytechnic in London with a "large" chemical laboratory, 49 ft. long and 25 ft. broad, is apt to create a smile.

Having thus sketched a hasty outline of what is wanted, let us now see how not to perform it. It is scarcely needful to say that the remarks which follow are not applicable to any one of the useful institutions now at work in London, and destined, if properly managed, to still greater usefulness. If in respect of any item the cap fits to any head, that is no affair of the present writer.

In order, then, not to organise a rational system of secondary and technical education, let a number of miscellaneous institutions be founded outside any governmental control, whether imperial or municipal, by philanthropic persons, sincerely desirous of benefiting the rising generation. Where the pious founder is not himself rich, or has no available trust fund to administer, let him secure on mortgage a piece of land, get a distinguished personage to lay a foundation stone, invite public subscriptions, construct a swimming bath, and run up a gymnasium, box off with matchboarding a few odd classrooms, get another distinguished personage to open the fragment of building, and then advertise in enormous posters, not only in the district but over all other districts where other institutions are already at work, that the grand new district polytechnic is open. Let the committee consist of the pious founder and his own immediate friends, all persons distinguished by their high character or by their wealth or philanthropy, and blameless too of any real experience of educational work. Let them select as their manager a thoroughly smart pushing man, who doesn't mind thinking that two and two occasionally make five, or whose alphabet contains only 25 letters, provided he can "enthuse" the affair and make it boom. It would not do for the manager to have too wide a knowledge of educational work, or think that his particular institution was not the greatest institution on earth. Let each manager advertise his institution by big placards in every district of London as the pioneer institution for secondary education. When placards cease to draw, get up a big concert, and when concerts begin to pall, a boxing match in the gymnasium, or an excursion to Timbuctoo for the Christmas holidays or failing this, an exhibition of students' work. Exhibit the same piece of workmanship twice, once with a label on it stating that it is the work of the students, then a year later with a different label, stating that the ornament only, not the solid structure, is students' work. Let copies be exhibited as original designs by students. When time is so short that the students have not much of their own work to exhibit, engage workmen at 9d. per hour to finish up their pieces, and when the bill comes in half a year later (amounting to a trifle under £200), carefully arrange matters so that this item never appears in any public statement of accounts. Exhibit a whole suite of furniture, constructed in barely three months by a single apprentice, it will not fail to excite remark. When a teacher is to be appointed, do not advertise the post, lest the most competent men should be deterred from applying, but let the Committee find their own men. Let them put in one because he is the brother of somebody else, or because he has compiled a book out of other people's books, or because he once passed an examination at South Kensington. Or, if a teacher is successful in persuading his students to do some real work, let them dismiss him and put in some other man who can be guaranteed to cram them up to earn Government grants.

Furthermore, carefully cut off all chance of the management of such institutions from the School Board, which has control of the primary schools. Arrange matters very carefully, so that, whilst the primary schools are under one Government Department, the only mode of Government subsidy to the secondary schools shall come through another Government Department. Especially make sure that there shall be no payment except on results of examinations: you may then be pretty sure that the examinations will be the only result of the payment. Turn the classes into a machinery for grant-earning, and substitute for the craftsman as instructor a teacher who can be duly trusted to grind his scholars into the proper examinational-groove. Sacrifice everything to make a show of numbers; numbers always tell on the public ear: give them quantity, show how many thousands of students are being instructed, and the public will be too dazzled to make inquiries as to the solidity of the instruction given. Publish an institute journal, the pages of which shall be conspicuous by their want of educational knowledge, and fill it with weak novelettes, tempered with glowing accounts of the doings of the amateur brass band, of the concertina chorus, and of the football clubs. Let each institute insist on teaching the same set of subjects, regardless of local fitness, each apeing whatever the others do. Lastly, let each of the institutes so constituted proclaim itself the equal of the famous technical schools of Zürich and of Munich by dubbing itself a "Polytechnic."

Every one will of course say that such a picture is overdrawn. If it errs, it errs in being underdrawn—that is to say, it errs by avowedly leaving out those social and non-educational matters in which great success has been attained, enumerating only in one those things which educationally ought not to be done.

But the policy of how not to do it has been carried still further. Only once in a generation does it occur that any Minister or body of Government officials has the chance of doing a really great thing in the furtherance of a great movement. Only once in a generation does it happen that an income approaching such a sum as £100,000 per annum can become suddenly available for promoting educational work in a great city like London. Such a chance occurred when, by the passing of Professor Bryce's Act, in 1883, the funds of the City of London parochial charities were available for redistribution at the hands of the Charity Commissioners.

The Charity Commissioners, after making ample provision out of these funds for certain vested interests, had a splendid margin with which to work. Their duty in the matter of redistribution was defined by the Act, making it clear that they were to frame a scheme to redistribute the funds for the benefit of the poor, partly by providing open spaces as recreation grounds, partly by aiding education. For years it has been known, our ablest educationalists have reiterated it, that the most crying want of London was the organisation of a system of secondary education. The higher elementary schools, such as are so successful in many provincial towns and cities, hardly exist in London. A few isolated schools, such as the Middle Class School in Cowper-street, the United Westminster Schools, and the St. Thomas Charterhouse Church School in Clerkenwell, have struggled on bravely, awaiting the organisation of secondary education, which should put them upon a solid basis, and adopt them as an integral part of the educational machinery of the metropolis. For higher education there have been, on the one hand, University College and King's College, and on the other, the Normal School of Science, the Central Institution for Technical Education (the only true Polytechnic in London) and the Technical College, Finsbury. There existed also a number of scattered classes, maintained chiefly under the Science and Art Department, some of them being held in special buildings, such as the Onslow College, the Aldenham Institute, the City of London College, the Bow and Bromley Institute, the Birkbeck Institution. There were also some classes for adults, such as the Working Men's College. About the same time Mr. Quintin Hogg was removing his Young Men's Christian Institute to the premises once occupied by Pepper's Ghost, and the Beaumont Trustees were arranging to reorganise their trust by creating a People's Palace at Mile-end.

The Act of 1883 required the Charity Commissioners to prepare a scheme, which in the course of last autumn duly saw the light. It is said that it is to be modified, but no modified scheme is yet issued. A careful reading of the scheme shows how completely the Charity Commissioners have failed to grasp the immense opportunity which lay at their feet. The money, which might have been used to create a real organisation for secondary and technical education, has been apportioned out in large blocks to certain institutions, some of which have only a hypothetical existence, most of which are of very recent origin, none of which can be said to constitute a direct link between the primary schools and the higher colleges. Most of these favoured institutions occupy a curious shelf in our educational history, being characteristic of the transitional time between the state of things as they were before the passing, in 1870, of the Elementary Education Act, and the state of things as they will be when that Act has been for a whole generation fully administered. Evening classes, excellent as they are from the transition point of view, are at best a lame expedient. Their success has been great, for the time favoured them. It may be doubted whether fifty years hence there will be either the same demand for or the same supply of them. If payment by results of examination is to be the means of supporting them, then the passing of last year's Technical Instruction Act is their doom. For if, under that Act, boys in the day-schools are brought up to earn the grants while at school, they cannot earn the grant a second time over at the evening classes after they have left school.

Yet, strange to say, characteristic perhaps of our tortuous and illogical British methods of movement, the Charity Commissioners' scheme deliberately passes over those three or four day-schools which have been carrying on, under great difficulties, some attempt at secondary education, and lavishes immense sums upon institutions whose day-classes are either non-existent or are educationally of a feeble order, and whose claims appear to be based upon the show they make of attendance in the evenings. Moreover, the Commissioners have adopted the incredible course of allocating their funds about inversely in proportion to the destitution of the institutions; those which were already in the possession of great sums having thousands a year allotted to them; while those like the Bow and Bromley Institute, and the Aldenham Institute in North St. Pancras, which have for years done good work on very slender pecuniary resources, are to receive as their grant a beggarly £150 a year out of the available funds. Furthermore, the Charity Commissioners' scheme does not fall into line with the administration of primary education. It does not place under the School Board of London the administration of the institutions which it proposes to endow. It creates for them a governing body on which the School Board of London is not even represented. Neither does it bring these institutions into line with the institutions for higher education. It puts representatives of the academic bodies, the University College and King's College, upon the governing body, but none from the Normal School of Science or from the City and Guilds Institute for Technical Education. This governing body is not under either the Education Department or the Science and Art Department, though it is to be hampered by codes laid down by the latter. It is not, indeed, under any department of Government, educational or financial, being responsible only to the Charity Commissioners for the time being. It is, however, a matter for congratution that two excellent institutions, both of which have done good work in this transition time, are to share in the redistributed funds, namely, the Birkbeck Institution and the City of London College. These are to unite, along with a third future institution, in an annual endowment of £5,350. This third institution, which is to be built upon land given by the Marquis of Northampton, appears, however, to be intended primarily as a recreative not an educational establishment, for it is part of the scheme (see clause 20 (*a*) of the draft scheme) that the duty of the governing body will be to erect first a large hall for public meetings; secondly, a swimming bath; thirdly, a gymnasium, and then some rooms applicable for technical and industrial instruction; but that the further extension of the building, mainly for the purpose of increasing the facilities for technical and industrial education, is not to come about until 1896!

As the result of the allocation of the available funds, the following sums are to be assigned:—

	Per annum.	Capital sum.
	£	£
Aldenham Institute	150	0
Bow and Bromley Institute	150	0
Working Men's College and College for Men and Women	400	0
Victoria Hall and Morley College	1,000	6,000
Hypothetical Chelsea Institute	1,500	unknown
Hypothetical Battersea Institute	2,500	"
Hypothetical Borough-road Institute	2,500	"
City of London College	5,350	51,100
Birkbeck Institute		
Hypothetical Northampton Institute		
People's Palace Institute	3,500	6,750
Regent-street Polytechnic Institute	3,500	11,750
Cripplegate Foundation	?	40,000
Bishopgate Foundation	2,000	40,000

The Charity Commissioners have thrown away, not too late, it is to be hoped, for Parliament to interfere, the opportunity afforded to them. Consider what might have been done. The ground was covered with organised primary schools; a nucleus of intermediate or secondary day-schools existed. The funds were available. Out of these elements there might have been erected such an organisation of secondary education as no other country in Europe can show; a system of secondary education not bounded by the old mediæval scholasticism that cramps almost all secondary education abroad, as it cramps the grammar schools at home, but broad based upon a scientific basis. That is what might have been. In place of which we are to have a number of mixed institutions, miscalled polytechnics, none of which have yet been long enough in existence for any one to be able to calculate upon their permanence, the sole value of which, from an educational point of view, is that they appear to meet a want arising out of the transitional time consequent on the Elementary Education Act of 1870, and on the lack of a proper system of secondary schools in the daytime. If the Charity Commissioners purposed or intended that these new institutions should serve the latter purpose, their policy would be more intelligible; but they expressly exclude this view, and insist that the funds they allocate shall not be spent in the maintenance of day secondary schools in these institutions. If there are day schools in these institutions they must charge such fees as will make them self-supporting. The whole policy of the Charity Commissioners in this matter appears to have been dictated by enthusiasm rather than by reason. By endorsing the system of remuneration through grant-earning on results of examinations, by lending themselves to the creation of huge social clubs without any guarantee of the solidity of their educational work, by favouring a crude system of combined philanthropy and advertisement, and, lastly, by the gross inequality of their allotments to the various districts, they have, it is to be feared, hindered rather than helped forward the cause of education.

The name of technical education, so little understood, so wofully misused, has been put forward so prominently in connection with these recreative and social institutions that many persons are actually under the impression that it was almost originated in them. Should any of these institutions, existent or hypothetical, come to grief, an irremediable harm will have been done to the cause of true technical education by the way in which its name has been put forward in connection with these institutions. What does Spitalfields want? A weaving school, a true technical school, not a feeble imitation of the excellent social and recreative club in Regent-street. What does Clerkenwell want? A real metal-working, horological, and mechanical school, not a second-hand People's Palace. What does Battersea require? An engineering school, not a place for amateur photography, shorthand, and drum-and-fife bands. What does Hoxton want? A cabinet-makers' school, not a copy of the Birkbeck Institution. What does Bethnal-green want? A leather-trades school, and she has got it, though not through the scheme of the Charity Commissioners. To each district its own appropriate school should be a primary consideration.

This is not what we shall get from the scheme now under review. We are much more likely to get schools resembling that provincial technical college which, in 1888, sent up several of its pupils for examination under the Science and Art Department to compete in seventeen or eighteen separate science subjects, and sent up one pupil in no fewer than nineteen subjects of examination. We have a right to ask the Charity Commissioners what they mean these institutions to develop into. Are they to be educational institutions? If so, why do they not provide for their being managed each one by an educational head; and why, in drawing up their schemes, do they persistently ignore or refuse the counsel of those who, like the headmasters of the existing secondary schools, could set them right? Or, are these institutions to be not educational but rather recreative and social? If so, then why, on the one hand, do they describe them by the term which appropriately describes the the great technical universities of Germany; and why, on the other hand, do they forbid in them smoking, dramatic performances, and dancing? The position is inconsistent: the public has the right to know what the Commissioners intend. Parliament cannot be expected to sanction a scheme so wofully crude in its inception, so ill-balanced in its parts, so defective in its details.

A not unimportant feature in the Charity Commissioners' scheme is furnished by the provisions (see City Polytechnic Scheme, particularly schedule III. section E) which make the Science and Art Department the authority which regulates the codes of instruction of the new institutions, and by which the income of these institutions is to be made in part directly dependent upon the earning of grants on the results of examinations, the instruction being expressly shaped toward the end of grant winning. At a time when public opinion is very rapidly becoming unanimous in condemning the system of payment by results in primary education, it is at least strange to find the Commissioners advocating it for their new institutions. But if payment by results of outside examination is bad in primary schools, it is ten times more disastrous in technical education. It destroys all spontaneity in teaching. To replace the craftsman by the crammer is the death of all that is technical. It is an amazing thing that in the national system of science teaching, systematic teaching in proper laboratories, subject to inspection, and administered under expert control, has never been recognised as furnishing any claim at all for the award of annual grants; that these have always been made on mere examinational results. If the codes of the Science and Art Department are now, as the Charity Commissioners' scheme seems to indicate, to be re-arranged to suit local needs, some much more radical change must necessarily follow. Of course it cannot be assumed that the Science and Art Department will accept so novel a proposition. That the local governing bodies should themselves draw up their codes, and submit them to the Science and Art Department for approval, may be a step in the right direction but it rests with that Department whether it will so use its power of approval as to make the step of any real value. Should it refuse to approve everything beyond the borders of the cut and dried code of the Science and Art Directory, the local freedom apparently granted by the Charity Commissioners' scheme becomes a pure delusion. Far better would it be to hand over the whole organisation *en bloc* to the Science and Art Department, which would then be compelled to reorganise a large part of its work, take in new blood, frame newer and more elastic codes, and adapt itself really to local needs. This would be infinitely better than leaving the organisation under the control financially of one body and educationally of another. Is there, however, any hope that the Science and Art Department would agree to this? Have they ever been asked to do so? Have they ever been consulted by the Charity Commissioners in the drafting of their schemes? No minutes of the Department on the matter have yet been published: is it possible that the Science and Art Department never was consulted? Men whose experience is as wide as that of Major-General Donnelly and Captain Abney, are certainly persons whose opinions on a future organisation is worth having, especially if in that future organisation they are to occupy the position of holding an educational veto upon the codes and the grants upon results of examination.

The Science and Art Department has in truth shown, during the past two years, that in spite of the incubus of official routine and red-tape, it is not wholly destitute of the instinct of progress; nay, that it can move, if with slow belated step, yet forward in the right direction. Many hard things have been said, not without some strong justification in the main, about the defects and limitations of the Department. To some of the more glaring of these the correcting hand has been applied; and a reference to the current Directory of the Department will show numerous points of amendment. The alternative course in Elementary Chemistry and that in Elementary Physics are instances; the abrogation of the rule that any graduate of any university in the United Kingdom is *ipso facto* considered as competent to earn grants by teaching all or any of the five and twenty specific science subjects is another. The limitation of payment on results on any individual candidate to not more than two subjects, other than the mathematical ones, is another excellent correction. The limitation of grants on candidates in mining, navigation, and agriculture, to the case of candidates who are actually training for those respective industries, had long been wanted. Lastly, the recognition as a qualification for teaching in science classes of the "specially qualified person," who is neither a graduate or a holder of South Kensington certificates, is the first sign of official recognition that the proper teacher should be a specialist in the subject he undertakes to teach; though here the official recognition is only to be given, as the Directory is careful to state, "exceptionally." Sooner or later that word "exceptionally" must disappear; for the man who is wanted to teach such a subject, for example, as building construction, is not the university graduate, not the holder of certificates of examinations for which he was once successfully crammed; but the man who has worked as a builder, and knows, not by superficial contact, but by years of training, what building construction is. It is the graduate and the holder of examination certificates, who are not builders, to whom the restricting word "exceptionally" ought to be applied. They should not be allowed to teach building construction, or any other such industrial science, unless they are exceptionally qualified.

This is neither the time nor the place to dwell on further urgent amendments in the codes of the Science and Art Department. The need of reform in some—for example, in the syllabus of the electrical subjects—is only too apparent; and their mathematical programme is deplorably academical. It is impossible to overstate the good which the Science and Art Department might effect, in reforming and modernising the teaching of mathematics, if only it could be induced to recast its syllabus of mathematical stages.

Before leaving the subject of the Science and Art Department, we must, however, refer to one other phase of the examination question. If the teaching in technical schools over the United Kingdom is to be brought into really intimate relation to local industries, it will in some subjects become impossible to conduct a fair examination on the plan hitherto adopted, of printing in London a single set of questions to be answered by candidates all over the country. Take, as an example, the subject of building construction. Practice varies so greatly in different parts of the country that an answer that might be right according to the practice in one district might be wrong according to that in another. The writer has heard teachers of classes in Scotland complain bitterly of the injustice done to candidates in Scottish classes by the questions being drawn up by a Londoner who did not understand the solid Scotch ways of building. This is no trifling matter, because if such local differences of technical practice are to be ignored or glozed over by confining the questions to general topics and abstract principles, the examination ceases to be any test at all of technical training. The very names of tools differ amongst the workmen in different parts of the country. What one set of workmen call a "rabbet plane" another set call a "gillam," and another set a "square plane." London carpenters use two special varieties of plane which they know as a "side pilaster" and a "sash pilaster." For these the Scotch names are both more expressive and more correct; they call them a "fore-check" and a "back-check." The mode, again, of describing the dimensions of parts differs in different districts. Suppose the bead at the edge of a jamb is to be described, a Scotch builder measuring it would describe it, say, as a half-inch bead, whilst a London builder, describing the same object, would describe it as a nine-sixteenths bead; for the London practice is to include in the term bead both the reed and the quirk beyond it, whilst the Scotch practice includes the reed only. There are scores of other examples that might be given from different industries, all pointing the same moral—the need of such a change as shall make the remuneration of training depend on the training, and not on the result of written answers to an examination paper set by an absent examiner.

One of the difficulties that arise in technical subjects is curiously illustrated by the paper set in carpentry last spring, under the technological examinations of the City and Guilds Institute, the examiner being a well-known architect. The candidate being asked to specify the form of section for maximum strength of a beam whose total cross section was 105 square inches, would have been quite right if he had described the form of section as either that of a girder infinitely deep and infinitesimally thin, or as that of a hollow tube infinitesimally thin, and of infinite diameter. But of course neither of these solutions would have been accepted as an answer to the conundrum, though none more correct could have been given.

Turning to another aspect of the organisation of secondary education, of scarcely less importance than its relation to Government departments, is its relation to local labour organisations. One would have thought that one very sure way to court failure would be to leave out of sight everything relating to the labour organisations. Yet this also the Charity Commissioners have succeeded in doing in their scheme. They provide no place, either on the central governing body nor in the constitutions of their detailed schemes, for the representation of any of the labour interests. This ought not to be. On the contrary there ought to be the frankest recognition of the fact that only those who know the several industries from within are in a position to give advice and information on many matters that will from time to time arise. The presence of such representatives on the governing bodies would go far to prevent the occurrence of many of the errors into which a purely philanthropic adminstration wouid certainly fall. With such representatives on a governing body it would be quite impossible for a teacher to be appointed to instruct some hundreds of youths in the subject of building construction whose sole qualification (beyond certificates of examinations for which he was "prepared" years ago) was that he had at one time worked as a packing-case maker. With proper labour representatives on the governing body. it would be certain that none but an engineer would be allowed to teach engineering subjects, none but a trained builder building subjects. Such men would stand no amateur nonsense in the matter of technical instruction.

If Parliament does not feel itself yet prepared to reject the Charity Commissioners' scheme, it might at least secure the appointment of a Special Royal Commission to revise it, and bring it into line with the organisations for primary and higher education.

This brings us then finally to the question, the critical question, in respect of the Charity Commissioners' scheme, what is the final aim and object of the institutions which it is now proposed to create and subsidise? Are they to be real educational institutions or are they not? Is their educational work to be real technical work, or is it to be examination cram? The two are simply incompatible. Consider the following fact in its proper bearings. In the plans of one of the institutions which it is proposed under this scheme to subsidise with thousands of pounds annually, and which is situated in a locality densely peopled with engineers, fitters, turners, smiths, carpenters, and builders, the space apportioned out for teaching the subject of photography is actually rather larger than that apportioned out for engineering drawing; whilst there is no space at all allotted for the purpose of a laboratory for teaching experimentally the principles of pulleys, levers, struts, the flexion and torsion of beams, the friction of surfaces, the strength of materials, and other essential parts of theoretical and applied mechanics. Yet schemes like this may read on paper very prettily indeed. Is there not at the Regent-street Institution a flourishing and popular class in photography? Then of course all the other institutions, whether at Mile-end, Shoreditch, Borough-road, Northampton-square, Chelsea, Battersea, or Paddington, must have a photographic class too—and call it Technical Education, with a capital T, for the People, with a capital P. What is, indeed, the aim and object of the institutions which it is proposed to create and subsidise? Is it to give real aid in the development of the local industries, to train in the application of scientific principles to those local industries, to train in technique, or is it merely to furnish an amateurish smattering of scientific odds and ends? Is it their aim and object to help the local industry, or is it—to borrow a very expressive phrase—merely "to gild the leisure" of the artisan?

For the latter purpose some features of the already established institutions appear to be most admirable. Their value as recreational and social agencies can hardly be overrated. They furnish a new and wholly commendable type of artisan club, with humanising influences, though their tendency toward the cultivation of taste cannot be said to be very pronounced. If they can keep their weekly journals free from the slang that debases them; if their entertainments do not degenerate into peep-shows, or boxing matches—a tendency already evident—then they may fill, quite apart from all educational efforts, a most useful and valuable place amongst the junior lower-middle and artisan classes of the population.

But recreation is not education, and social betterment is not the same thing as educational progress. Success in answering questions set in a paper, is at best only a paper success; and education which is not technical is not technical education.

DISCUSSION.

Dr. GLADSTONE, F.R.S., said this paper contained a large amount of thought clearly and strongly expressed, and he agreed with Professor Thompson on the main lines of his argument, though there were some remarks which were perhaps a little exaggerated. He had done a great service in drawing attention to the want of organisation of secondary instruction, and to the effect of that which was being proposed by the Charity Commissioners towards supplying the needs. Elementary education was fairly well organised, it was very good and was becoming better; the main difficulties being connected with the Education Department, which he hoped would soon be removed in great part, if not altogether. Higher education also was good, but the lower secondary education was inferior, most of the schools being conducted by those incapable of teaching, the methods employed inadequate, and the subjects not suited to the present advanced stage of civilisation. He did not mean that there were not excellent secondary schools in England, but he feared a great many were as he had described. At present elementary education was improving in quality and extending in quantity, and many of those who used to send their children to small private establishments now sent them to the elementary public schools, especially to those in which a higher scale of fees was demanded. The question was whether this would continue to go on, and whether more of the young people of the class to which he referred were being brought into the elementary schools; and, again, whether if there were many of these higher elementary schools established, they were to be, to a large extent, subsidised by the Government. Then would come the question whether secondary schools were to be inspected simply, or also subsidised. The second point in the paper was that many of the proposals took for granted what was a transitional state of affairs, and endeavoured to adapt plans on a very large scale to it; but little else but disaster could come from such a course. The purpose of the Polytechnic establishments was good to a certain extent, but every such step should be taken with great caution, so as not to make gigantic blunders in establishing a state of affairs which it might be difficult to get rid of. Education was one thing and recreation another, both were good in their way, but it was very difficult to combine them in one institution without the educational part becoming to a certain extent subordinate. He hoped there would be institutions of both kinds, but he felt some alarm at the attempt made to combine the two. Attempts had been made to bring in Bills to promote evening and continuation schools, and a deputation was going to the Department on the following day on this matter. He did not think they were as great a success as was claimed in the paper, but they might be improved, and there was large scope for them in the future among those who were obliged to earn their living when still young. The present Technical Education Bill might be of service in some parts of the country, especially in the north; but he did not think it would be much taken advantage of in London. They would rather wait and see whether it was not improved and brought into co-ordination with the School Board system, so that in some way there might be proper organisation of education from the lowest grade right up to the highest.

Mr. E. C. ROBINS thought there was a little dissatisfaction in the public mind with regard to these educational and recreative establishments, and they had not yet heard sufficient details to feel that so large an expenditure in this direction would be justified, but as attention was now being drawn to the matter, possibly some improvement might be made in the scheme. The City and Guilds Institute went to work in a very different way when they wanted to establish their institution. They obtained essays from men like Professor Huxley, Lord Armstrong, and others, in the first place, and afterwards associated with themselves the Presidents of the Institution of Civil Engineers, of the Chemical Society, the Royal Society, and the Chairman of the Council of the Society of Arts, as *ex-officio* members of the body, so that there should always be the highest intellect of the day to assist in their deliberations, and to assist the organising director. In contrast to this was the work of the Charity Comissioners, which seemed to be entirely founded on a successful novel of Walter Besant's. The main idea was that people wanted recreation much more than education. That was well illustrated in the Northampton plan, in which six years were to elapse before anything was done in the way of education, but, in the meantime, a good deal of recreation was to be provided at once. In these days London was only too well supplied with theatres and music-halls, though he remembered when there were few of the one and none of the other, and he thought the public were very well supplied with the means of amusement. The only true enjoyment was in feeling that you were learning something, and doing something to help on the progress of your fellow men, or of your country, or of something in which you took a personal interest; all kinds of mere amusement soon palled, and were little better than waste of time. But the working people of the present day were supposed to want more of this kind of amusement than their forefathers. He was pleased to hear Professor Thompson speak with respect of South Kensington, because after all it was the most important Government institution connected with technical education in the country in general. What was wanted, was not so much to educate the lowest class as to improve the applied art education of those above them. It was that which had enabled Germany and other countries to compete with us so severely; forty years ago they took steps to give the middle educated classes opportunities of acquiring not only literary but scientific education. In Germany the schools were arranged quite differently to ours; there were those which led to the University and those which led distinctly to the science Polytechnica. We had only just begun to take the same course, and the example set by the City Guilds was a most excellent one. He had hoped that this scheme of the Charity Commissioners would have been more of the same character, and would not have gone so low down in the scale as they seemed to have done; but unfortunately the interest shown by the public in these polytechnics had even led some of the City Companies to assist in the scheme, to the detriment of their own work. There was much more of their work yet to be done, and he was sorry to see such large funds diverted into another channel, where he feared it would not be nearly so useful.

Mr. G. N. HOOPER said they had all been groping in the dark a good deal as to what technical education really was, but Professor Thompson had shown them what should be aimed at. A great deal of money might be wasted if expended too hurriedly, and it would be far better to pause a little, and to ascertain exactly what was wanted. Although the matter was in a transitional state, some of the institutions named had done good work, as they had helped to elevate many young men from grosser enjoyments to those which were more intellectual. The report of the Royal Commissioners on Technical Education, and Mr. Matthew Arnold's report on the schools of the Continent, ought to have given a good deal of information, and he hoped now they would be able to go forward with more certain steps. Professor Thompson had pointed out the difficulty which arose from London examiners setting papers for the whole country. He had been anxious to get a number of text-books prepared applicable to the industry with which he was connected, which should be thoroughly representative, and to that end he thought of having them prepared by one man and edited, revised, and criticised by others in different parts of the country. As manager of a technical class he fully appreciated the remark that the teachers should be skilled artisans, who had undergone science teaching. Some years ago, acting on that principle, they sent a clever young Scotchman over to be trained in Paris; he spent some time there, became a distinguished student, and then, returning to this country, became a teacher, and had trained quite a body of teachers, who had spread similar classes all over the country. In the United Westminster Schools they had in operation a very successful chemical class, and had just built a classroom for metal-working. The chairman of the council, Sir Sydney Waterlow, was anxious that this class should be thoroughly practical, and that special attention should be given to the probability of many of the boys becoming colonists hereafter. There was an endowment by the aid of which they were able to take some of the best boys from the Board schools, the training being of a much higher class than was given there; but it was found in fact that the system of training was so different that there was quite a break, and some difficulty experienced in passing from one to the other. It would be a great improvement if the schools were so graded that the pupils could pass straight on from one to the other without such a break. It was much the same in the case of a large endowed girls' school. The mistresses of the Board schools did not like to part with their most promising girls, and there was sometimes great difficulty in getting them away, because it lowered the average of the Board school.

Mr. NICHOLLS said he was somewhat surprised at not finding a few artisans present, but when educational questions arose the very men most interested were absent. All the attention was being given to education, and little or none to training, and the result was that practical men found it very difficult to carry on their business. This was especially the case in the country with regard to agriculture and mechanics, and even the landlords and the upper classes were perfectly ignorant of practical matters. If they were trained to agriculture and mechanics, those below them would copy their example; the land would be better cultivated, and young men would be retained in the country, and would be able to earn their living, who were now obliged to come into the towns.

Mr. BOND said the remarks of the last speaker encouraged him to put a question with regard to technical education in the provinces, and how it might be advanced in connection with agriculture and horticulture. Much had been done by the colleges at Cirencester, Aspatria, and other places, which were endeavouring to supply that technical education which had been described as training. He represented a somewhat similar institution, which was quite unique in England, where they were endeavouring to teach everything relating to the science and practice of horticulture. There was a great difficulty in finding men as teachers who were both scientific and practical; they therefore had to depend on practical men and professors. Of course the training without the college ought to coincide with the teaching within it, but this was not always the case. Practical men had their notions, and although they stumbled on the truth in a remarkable manner, and many of them were very able men, they were very jealous of any interference from a scientific man, and that made it difficult to teach the chemistry of the subject, and to see it carried out in the practical training outside.

The CHAIRMAN, in moving a vote of thanks to Professor Thompson, said his criticisms had been both recreative and intellectual. A great deal of the paper had been devoted to criticising the scheme of the Charity Commissioners, and in the main he agreed with him, but he thought he had perhaps forgotten one or two of the difficulties which the Commissioners had to meet. They were bound to carry out the City of London Parochial Charities' Act, and the general tenor of their instruction was to propound schemes for various matters; technical education was mentioned, no doubt, but only in a subordinate place, and, therefore, whatever they thought of the matter, they could not give a preponderating place to the subject in the scheme. They were bound to take into account recreative schemes and open spaces. Technical education was most valuable, and was most of all needed in this country at the present time, but there were other necessities also connected with our social system. The means of life for the poor were rather dark and cloudy, and recreation must not be forgotten. With regard to the governing body, the Commissioners were not altogether at fault. In the Act of Parliament it was laid down that four of the representatives—of whom there were to be 15—should come from the Common Council, and five were to be nominated by the Crown. He hoped when the Crown made its nominations one of Professor Thompson's suggestions would not be forgotten, and that some representatives of the labour organisations would find their place on the governing body. Then he believed that another representative was to come from the Bishopsgate and Cripplegate Charities, so that it only left six to be filled up. University College and King's College had two each originally, but he understood that in the amended scheme they were cut down to one each, and two were to be given to the London School Board, two to the London County Council, and one to the City and Guilds Institute. Professor Thompson had spoken of "gilding the leisure of the London artisan," and he thought there was a good deal to be said for that. The hours of labour would probably be shortened, and the leisure lengthened, and they would not give up the whole of their leisure to education, technical or otherwise; it was therefore highly desirable that their play should be organised, and made as intellectual as possible. The swimming-bath was a very good form of recreation, and he was by no means inclined to minimise the good results which flowed from it. Apart from the question of cleanliness, swimming was valuable as an athletic exercise, and it was very desirable that men coming to London should be able to keep up in some form the love for athletic exercises which they brought with them from the country. He deeply regretted that these institutions were to be called polytechnics, which they certainly were not, and he thought it might have been possible to find a more appropriate name for them. Another point to be remembered was that the Act of Parliament laid great stress on these endowments, which were originally intended for the very poor, being still devoted to their benefit, and it was impossible therefore to apply them principally to secondary education. It was certainly in the interest even of the very poor that secondary education should be organised, and the Commissioners might have paid more attention to the idea of giving clever boys from the Board schools the opportunity of extending their education. The great difficulty always was that parents could not forego the earnings of their boys for a long period; and if the Commissioners could have seen their way to help in this direction, so that boys of talent might continue their studies to the age of 17 or 18 years, it would have been a good thing. There were many boys in the elementary schools whom it would be well worth while for the State to train by aid of this kind, and he was not without hope that something of this kind might ultimately be done. In a few years, when some of the vested interests expired, and leases fell in, the surplus for disposal would be considerably increased, and, perhaps, the new governing body would attend to some of the suggestions which had been made, and remedy some of the defects which had been referred to. He did not think there was any likelihood of Parliament throwing out the scheme altogether, and they should rather, therefore, accept the position, and make it work as well as possible; and in that direction no doubt criticism would be useful. He hoped one of the first things to be done would be the appointment of an organising director, and if they could obtain the services of such a man as Professor Thompson, it would go a great way to ensure the best possible results being obtained.

The vote of thanks having been carried,

Professor THOMPSON, in reply, said he had not attempted to draw the line between what he considered primary and what might be considered secondary education. His view was that London had not yet got the higher elementary schools which were to be found in many of the large towns, and n the absence of that grade of primary schools, it was not a question of a line of demarcation, but of a great gap or zone. The fact that in these higher elementary schools, where they existed, the fees were higher, naturally suggested one point on which he had not touched, and that was the establishment of scholarships, which should carry onward the very poor from the cheap or free schools to the higher schools, so as to bring the secondary or higher education within the reach of the very poorest, and that would be an obvious way of carrying out the instructions of the Act. He had hoped to see a great scheme of scholarships established, something on the lines of that of the Mitchell Trustees, which began with the elementary school, and carried the poor boy on into the higher or middle-class school, and from that to college, until finally the picked boys went to the university. He knew that the carriage building industry had greatly profited by Mr. Hooper's own efforts, and was very glad to hear his suggestions as to the way in which teaching might be made more uniform in various localities. What he had referred to about the difficulty of boys passing from the Board schools into the United Westminster Schools furnished a cogent example of the dislocation, where one part of education was under one Department, and another under another or under none at all. Sooner or later, the Education and the Science and Art Departments must be brought together, and put under a Minister of Education, as every other civilised nation—Japan included—had already done. The further remark about the girls whose schoolmistresses wanted to keep them back was another instance of the disastrous effect of payment by results. Mr. Nicholls appeared to have slightly misunderstood the use of the word education, and he used the word training in almost exactly the same sense in which the words technical education were used in the paper; it was that which he wanted to see substituted to a great extent for what Mr. Nicholls called education. It was unfortunately true that horticulture was very much neglected. He believed it was possible to get a horticultural education by going to Holland, and he knew one or two who deliberately spent a couple of years there to learn that science, but it was an expensive and troublesome process. The same difficulty almost applied to the science of forestry; there was no school of forestry in England, and one result was that there was hardly an Englishman living who knew how to keep Kensington Gardens in order. If any attempt were made to establish a school of forestry or horticulture, the best authority to consult was Professor Marshall Ward. He entirely endorsed a great deal of what the Chairman had said; he knew the Commissioners had not a free hand, that they were compelled to provide money for recreation and for open spaces, and to make certain nominations to the governing body; but that did not justify their policy Because they had to provide for recreation and for open spaces as well as for education, it did not follow that they should support only a group of institutions in which a mixture of recreation and education was attempted. He thought it a mistake that they would not give any money to educational institutions which were not mixed up, and to a certain extent spoiled, by being to a great extent a recreational institution. To refuse to support a purely educational institution because it was not mixed up with a recreative institution, would be as absurd as to refuse to support it if it was not in the middle of an open space. There was not a line in the Act of Parliament which they were administering to suggest that the endowments should be given to mixed institutions. It appeared to be useless to point the Commissioners to the fact that a weaving school was wanted in Spitalfields, a metal trades school in Clerkenwell, and a building school in Islington. The Commissioners apparently were determined not to support any strictly technical school; they would only give to institutions which spoiled their educational side by attempting smatterings of all sorts of subjects, and mixed up education with recreation. He had not a word to say against recreation or open spaces, they were both excellent, but they were not educational, and that was his topic and point of view. Neither did these considerations justify the extraordinary inequalities in the amounts allotted to different localities. He wanted to know why the People's Palace, which was rich, should have given to it an annual grant twenty-three times as large as that given to the Bow and Bromley Institute, which was poor. He was very glad to hear that possibly the labour organisations, the School Board, and the City and Guilds Institute were to be represented on the governing body, but it was quite news to him, for only last Friday he had inquired if any amended scheme was ready, and was told it could not be procured. But the improvement of the central governing body was only one small item. The subordinate schemes which provided for the local governing bodies contained no provision for labour representation, or for the selection of people having weight in matters of education, saving in one case, that of the City Polytechnic, which was to consist of persons appointed from the Birkbeck Institutions and the City of London College. He thoroughly agreed that money should be spent in organising play, and in gilding the leisure of the artisan, only that was not education; and when money had to be spent on education they were entitled to ask the question—In spending these thousands of pounds, do you mean this new building to be what it is called, or do you mean it to be a mere place for organised play? The question was—Did they mean to play at education in these places, or were they to be real centres of instruction?

Miscellaneous.

JAMAICA EXHIBITION.

The arrangements for holding an Exhibition in Jamaica in 1891 appear now to be fairly complete. The Exhibition is to be opened on the 27th of January, 1891, and to remain open for a period of not less than three months. It will be managed by a Commission, of which the Governor of Jamaica is at the head.

The Exhibition will comprise specimens of all Jamaica products:—Sugar of all qualities and its allied industry of rum manufacture; liqueurs, cordials, &c.; coffee; oranges, pine apples, and fruits of all kinds; pimento, cacao, annatto; woods in all degrees of preparation for use; spices, condiments, &c.; fibres and fibrous materials; cinchona bark, oils, essential oils, perfumes, &c.; medicinal and economic substances; works of art, pictures, fancy articles and ornamental work; horses, cattle, and live stock of all kinds. The botany and geology of the island will also be fully illustrated.

The Exhibition will also contain examples of foreign products imported into Jamaica. The date given for the receipt of applications for space is the first of May next. No charge is to be made for space. A guarantee fund of over £23,000 has been raised in the island, and this, it is believed, will nearly suffice for the purposes required. A committee to ensure the due representation of British industries has been formed in London. Mr. Washington Eves, C.M.G., is the chairman, and at the request of the committee the Council of the Society of Arts have nominated one of the members, Mr. C. M. Kennedy, as a member of that committee. For further information application should be addressed to Mr. Washington Eves, 1, Fen-court, E.C.

Correspondence.

TEA INDUSTRY OF CEYLON.

Mr. J. L. Shand sends the following extract from a letter from Mr. James Taylor, of Toolecondera Estate, dated 25th June, 1888, which gives, on undoubted authority, the dates of the first importation into Ceylon of Assam hybrid tea seeds, and also of its first successful planting. The first tea was sold in Kandy early in 1872, just about the time of the arrival in the colony as governor of Mr. (now Sir William) Gregory, who at once paid a visit to Toolecondera to see what was going on there. Mr. Taylor writes:—"The first Assam hybrid tea seed arrived here in the early part of 1868. That lot all failed, and our second lot came in the first days of 1869, and our clearing of 20 acres was planted with the plants from this seed in the latter part of the same year. Tea was first planted on Toolecondera in 1866 along the roadsides. This was China tea, the seed of which had been got from the Peradenia gardens and the plants raised here in small nurseries. Our tea house was built in 1872, but some tea was made for sale before that, and we had been making it experimentally for years before. Our first experiment was about 1866, when an Assam planter passing through showed me how to do the rolling, and told me about the rest of the performance. This was with leaves off old tea bushes in the garden at my bungalow."

UTILISATION OF SLAG.

In his exhaustive paper on this subject, Mr. G. Redgrave did not refer to a method in which blast-furnace slag may, in many cases, advantageously be utilised. This consists in filling in block slag into the excavations in collieries, so as to support the superincumbent strata. In this way considerable economy has been effected in a number of German collieries, notably at the Gräfin Laura Colliery in Upper Silesia, where a large amount of coal had formerly to be left to support the surface, as the workings are directly under the town of Königshütte. The slag is lowered into the workings by a self-acting incline from the adjacent ironworks, the cost of transporting the slag and of stowing it in the workings not exceeding 6d. per ton. In whatever way the slag is utilised it is highly desirable that it should be economically transported. A method, in which all handling of the material is dispensed with, I saw in operation last summer at a number of iron-works in the Siegen district, Westphalia. There the slag runs from the blast-furnace into a channel of rapidly-flowing water, which granulates it and carries the fine sand to a large iron holder. From this it is automatically charged into the bucket of an "Otto" aërial wire-rope tramway, which transports it to a slag heap at a considerable distance from the works.

Bennett H. Brough.

Royal School of Mines.

Mr. Henry Faija writes that when he experimented with the "Improved Cement" he found that it had none of the characteristics of Portland cement, and he unhesitatingly condemned it. He adds, "On Table III. Mr. Redgrave tells us that English Portland cement gauged with three parts of sand carries at twenty-eight days 62 lbs., and this is going forth to the world as English manufacture. The late Mr. Grant's tests at the Metropolitan Board of Works was 270 lbs. for the sand-test at twenty-eight days, and he always got cement to carry this strain; and as Mr. Grant was the exponent of the sand-test in this country, I am perfectly certain that he would not have accepted the cement mentioned in Table III. as representing "one of the best English cements."

MODERN IMPROVEMENTS OF FACILITIES IN RAILWAY TRAVELLING.

Captain Fairholme writes, with reference to the report of his remarks on Mr. Findlay's paper, that the Prussian Government have created a network of local lines, which are of the normal gauge, so that all the goods waggons of the main lines can run over them. The *chemins de fer vicinaux*, in Belgium are metre-gauge light railways, which are being largely built by a private firm with a State guarantee.

Mr. S. Chapman writes:—As regards second-class traffic, Mr. Findlay's view of the social aspect of the case seems a very reasonable one, yet there remains the fact that second-class traffic is on the decline, whether as regards actual numbers conveyed, or receipts. Without giving more details, I would just show a comparison between 1883 and 1887, based on the traffic for the whole of England and Wales. We find—

	1883. per cent.	1887. per cent.
The per-centage of 2nd class passengers to the total conveyed	9·65	8·95
Receipts (including season tickets)	15·59	13·64
Receipts (excluding season tickets)	13·90	11·58
Giving average per passenger (excluding season tickets)	£ ·0484	£ ·0414

It is evident the great bulk of the second-class traffic is for short distances, and this is no doubt largely accounted for by the objection the middle-class have to travelling with the working classes proceeding to and from their duties in a more or less unavoidably soiled condition, coupled with the very cheap second-class season-ticket rates, the tendency naturally being that anyone holding such a ticket would, in most cases, take tickets of a corresponding class for friends when accompanying him. Now, on the long journey trains the workman element ceases, the poorer classes are mostly travelling on private business, and the objection on the score of cleanliness against travelling with them is in the main removed, and it seems a question whether, looking at the matter all round, the policy of the Great Northern Railway in abolishing second-class where but little used, and retaining where appreciated, does not best meet the case.

General Notes.

Frankfort Electro Technical Exhibition.—Information has been received from the Secretary of State for Foreign Affairs through the Science and Art Department that this Exhibition, which was announced to be held in the present year, has been postponed until 1891.

Exhibition of Meteorological Instruments.—The Council of the Royal Meteorological Society have arranged to hold at the Institution of Civil Engineers, on March 18th to 21st next, an Exhibition of instruments and photographs illustrating the application of photography to meteorology. The committee will also be glad to show any new meteorological instruments or apparatus invented, or first constructed, since last March ; as well as photographs and drawings possessing meteorological interest.

MEETINGS OF THE SOCIETY.

Ordinary Meetings.

Wednesday evenings, at Eight o'clock:—

February 26.—Arthur Montefiore, "The English in Florida."

March 5.—J. Tripplin, "Recent Progress in British Watch and Clock Making."

March 12.—Sir Douglas Galton, K.C.B., D.C.L., F.R.S., Vice-President of the Society, "The Chemin de Fer Glissant, or Sliding Railway." Sir Frederick Bramwell, Bart., D.C.L., F.R.S., will presiee.

March 19.—J. S. Keltie, "Commercial Geography."

March 26.—G. N. Hooper, "Carriage Building and Street Traffic in England and France."

Foreign and Colonial Section.

Tuesday afternoons, at Five o'clock:—

March 18.—James W. Wells, M.Inst.C.E., "Brazil."

April 22.—Sir John Stokes, K.C.B., "The Danube and its Trade."

A. Lasenby Liberty, "The Industrial Arts of Japan."

C. G. Warnford Lock, "Gold Mining in Hungary."

Indian Section.

Thursday afternoons, at Five o'clock:—

February 27.—William Sherriff (of the Rangoon Chamber of Commerce), "The Northern Shan States and the Burma-China Railway." Sir Charles Bernard, K.C.S.I., will preside.

Sir J. Theodore Hope, K.C.S.I., "The Rationale of Indian Railways."

T. Talboys Wheeler, "Old Madras."

[The Meetings of this Section will in future be changed from Fridays to Thursdays.]

Applied Art Section.

Tuesday evenings, at Eight o'clock:—

March 11.—James Orrock, R.I., "The Claims of the British School of Painting to a thorough representation in the National Gallery." Sir James D. Linton, P.R.I., will preside.

[Pictures by illustrious English masters whose works are not included in the National Gallery will be exhibited by Mr. Orrock.]

April 15.—C. Purdon Clarke, C.I.E., "Modern Indian Art."

May 13.—Prof. W. C. Roberts-Austen, F.R.S., "The Use of Alloys in Art Metal-work."

CANTOR LECTURES.

Monday evenings, at Eight o'clock:—

THOMAS BOLAS, F.C.S., "Stereotyping." Three Lectures.

LECTURE II. — FEBRUARY 24. — The Paper Method.—Adaptation of the process to the various requirements of rapidity, sharpness, and hardness. The paste. The flong. Dryness of the mould. Packing the high parts of the mould. The metal. Influence of foreign admixture. Use and abuse of French chalk. Moulds for making numerous casts. The surface of the casting-box. Relation of the temperature of the metal to the dryness of the mould. Quick moulding, and drying after removal from the type. General considerations as to casting type metal in paper moulds. Damage to type in stereotyping.

LECTURE III.—MARCH 3.—Various Stereotype Methods.—Casting in plaster moulds. Survival of the method for casting from music type. The copper electrotype backed with soft metal. Casts in brass and the more refractory metals. Softer stereotypes —Celluloid, india-rubber, gelatinous compositions.

POPULAR LECTURES.

Saturday afternoons, at Three o'clock:—

Professor VIVIAN LEWES, "The Atmosphere." Four Lectures.

March 8, 15, 22, 29.

ADDITIONAL LECTURES.

Thursday evenings, at Eight o'clock:—

LEWIS F. DAY, "Design applied to Wood-Carving." Three Lectures.

May 1, 8, 15.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, FEB. 24...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Thomas Bolas, "Stereotyping." (Lecture II.)

Hellenic, 22, Albemarle-street, W., 5 p.m.

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Mr. Charles Morris Woodford, "Further Explorations in the Solomon Islands."

Actuaries, Staple-inn-hall, Holborn, E.C., 7 p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. Arnold Mitchell, "The Rise of Early English Architecture."

TUESDAY, FEB. 25...Royal Institution, Albemarle-street, W., 3 p.m. Dr. G. J. Romanes, "The Post-Darwinian Period." (Lecture VI.)

Medical and Chirurgical, 20, Hanover-square, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on following papers:—1. Mr. J. W. Hart, "The Shanghai Waterworks." 2. Mr. Jas. Orange, "The Tytam Waterworks, Hong Kong." 3. Mr. J. H. T. Turner, "The Construction of the Yokohama Waterworks."

Anthropological, 3, Hanover-square, W., 8½ p.m. 1. Dr. J. G. Garson, "Exhibition of Stanley's Spirometer." 2. Mr. S. B. J. Skertchly, "Some Borneo Traps." 3. Mr. A. W. Howitt, "The Dieri and other kindred tribes of Central Australia."

WEDNESDAY, FEB. 26...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. Arthur Montefiore, "The English in Florida."

Inventors' Institute, 27, Chancery-lane, W.C., 8 p.m.

Geological, Burlington-house, W., 8 p.m. 1. Prof. Joseph Prestwich, "The Relation of the Westleton Beds or 'Pebbly Sands' of Suffolk to those of Norfolk, and on their Extension inland; with some Observations on the Period of the final Elevation and Denudation of the Weald and of the Thames Valley" (Part III.). 2. Mr. W. Whitaker, "A Deep Channel of Drift in the Valley of the Cam Essex."

Ladies' Sanitary Association, 22, Berners-street, W., 3½ p.m. Dr. J. Sinclair Holden, "Women's Help in Infectious Diseases."

Cymmrodorion, 27, Chancery-lane, W.C., 8 p.m. Rev. E. T. Davies, "A Study in early British Christianity."

Royal Society of Literature, 21, Delahay street, S.W., 1 p m.

Cleveland Engineers, Middlesbrough, 7½ p.m.

THURSDAY, FEB. 27...SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m. (Indian Section.) Mr. William Sherriff, "The Northern Shan States and the Burma-China Railway."

Antiquaries, Burlington-house, W., 8½ p.m.

Camera Club, Bedford-street, Strand, W.C., 8 p.m. Dr. C. S. Patterson, "The Camera as applied to Medicine."

London Institution, Finsbury-circus, E.C., 7 p.m. Sir Alfred C. Lyall, "The Rise of British Dominion in India."

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Mr. P. H. Newman, "Some Relations between Fine Art and Photography" (with limelight illustrations).

Royal Institution, Albemarle-street, W., 3 p.m. Rev. Canon Ainger, "The Three Stages of Shakespere's Art." (Lecture III.)

Electrical Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on the following papers:—1. Mr. James Swinburne, "The Theory of Armature Re-action in Dynamos and Motors." 2. Mr. W. B. Essen, "Some Points in Dynamo and Motor Design."

FRIDAY, FEB. 28...United Service Inst., Whitehall-yard, S.W., 3 p.m. Inspecting Veterinary-Surgeon W. B. Walters, "Casualties among Horses in the Field"

Royal Institution, Albemarle-street, W., 8 p.m.. Weekly Meeting, 9 p m. Prof. C. Hubert St Parry, "Evolution in Music."

Quekett Microscopical Club, University College, W.C., 8 p.m.

Clinical, 20, Hanover-square, W., 8½ p.m.

SATURDAY, MARCH 1....Société Nationale des Professeurs de Français (At the HOUSE OF THE SOCIETY OF ARTS), 3 p.m. Lecture.

Royal Institution, Albemarle-street, W., 3 p.m. Lord Rayleigh, "Electricity and Magnetism." (Lecture III.)

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FRIDAY, FEBRUARY 28, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CANTOR LECTURES.

The second lecture of Mr. Bolas's Course on "Stereotyping" was delivered on Monday evening, 24th inst. Conditions affecting the working of the paper-mould process were considered in some detail, and as an illustration of a possible means of quickening the production of plates containing the latest items of news, a cast was made from the wet paper mould in Wood's fusible alloy, which alloy melts at between 60 and 70 degrees Centigrade (bismuth seven parts, lead four parts, tin two parts, cadmium one part), and though the cast was rather granular, by reason of the crystallisation of the alloy, it was quite capable of giving a fair impression. As regards the selection of materials in the paper process, a protest was made against the very vague but common instruction to use "only the very best materials." In several instances the materials sold at the lowest prices were stated to be of the most suitable kind, as, for example, in the case of oil for the forme, the petroleum lubricant sold retail at one and sixpence a gallon being better than the "purest olive" or "finest lard oil" so often recommended; the petroleum not saponifying with any trace of alkali which may be left on the forme.

The lectures will be published in the *Journal* during the summer recess.

PRACTICAL EXAMINATION IN VOCAL AND INSTRUMENTAL MUSIC.

The next examination in London will be held by W. A. Barrett, Mus. Doc., at the House of the Society of Arts, and will commence on Monday, 2nd of June.

Full particulars can be obtained on application to the Secretary.

Proceedings of the Society.

TWELFTH ORDINARY MEETING.

Wednesday, February 26th, 1890; B. Francis Cobb, Treasurer of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Hederstedt, Henry Burdett, 74, Lancaster-gate, W.
Profumo, Baron Joseph, Parkhurst, Beckenham, Kent.

The following candidates were balloted for and duly elected members of the Society:—

Fawcett, Richard, Wirksworth, Derbyshire.
Gearns, John, 12, Finsbury-square, E.C.
Linnell, William, The Avenue, 76, Fulham-road, S.W., and Hillsbrow, Redhill, Surrey.
Moore, Alfred, Queen's-buildings, 2, Ridgfield, Manchester.

The paper read was—

THE ENGLISH IN FLORIDA.

By Arthur Montefiore, F.R.G.S.

In the gradual expansion of England, the wide limits of an Empire upon which the sun never sets have proved all too narrow for the energies and enterprise of her sons. Eastward and westward, northward and southward, in climates of kindred character, and in climates strange and unkindly—in short, all the wide world over—do we find the homes and settlements of our kinsmen. We recognise their colonial ability in the most unexpected quarters, and in many a queer and quaint corner of this earth is the traveller compelled to acknowledge, with gratitude begotten of experience, how wide—how delightfully wide—are the borders of Greater Britain.

For we not only find Englishmen sheep-farming in Queensland, wheat-growing in Manitoba, lumbering in British Columbia, tea-growing in Assam, or ranching in Alberta, but we also meet with them in Central Africa, developing in a hundred ways huge commercial states; in the Argentine, ranching and mining;

in the Sandwich Islands, growing sugar; in California, canning fruit; in Arizona, raising hogs; in Japan, China, Persia—in every part of the world, indeed—engaged in commerce; and in *one* part of the world, in the peninsula of Florida, growing oranges.

The orange is not by any means the sole product of Florida; but the fame of its excellence has been so widespread, and the rigid requirements which it makes upon the climate have given it such a prominence, that the phrase "Florida and orange-growing" has become as familiar in our mouths as household words.

I say that the orange makes rigid requirements on the climate. A mere glance at the map of Florida will, I think, reveal the why and the wherefore of that country being so admirably adapted for the sensitive *citrus* family. It will also guide us, I believe, to a similar conclusion with regard to many other semi- and sub-tropical plants and fruits.

You will have observed upon the map that the peninsula of Florida—and it is with its peninsula portion that we, as Englishmen, have to do—is an orthodox peninsula. For it agrees with the language of the geographical text-books, and is "nearly surrounded by water." It is therefore supremely dominated by marine influences. But this does not say enough. You will have noticed that it has on the west coast, as neighbour, the Gulf of Mexico—a cauldron-sea; and that there issues from the Gulf that vast body of heated water which we call the Gulf Stream, and to which we of Western Europe owe our moderate climate. For, divert that stream, which is swept by the trade winds—those children of the equatorial ocean—into the Caribbean Sea, and thence into the Gulf of Mexico; divert it, say, by a volcanic disturbance sufficiently energetic to remove most of the isthmus of Central America, and allow it to escape into the Pacific Ocean, and the result would be revolutionary. The British Isles would become polar in character, and as ice-bound as Greenland. The second Ice Age, in fact, would have arrived. A glacier might gravitate down John-street, Adelphi, with perfect decorum, and both the ruins of London and the skeleton of the impertinent New Zealander would lie, fathoms deep, beneath the snow. I cannot speak for you, but for myself, I say that I am unable to contemplate such a change with equanimity.

Well, what the Gulf Stream is to us, that also it is to Florida. It is simply the making of the country. It heats and moistens the winds that blow daily from the west; it performs the same service for those which blow from the east. That icy current which steals down from the Polar regions, insidiously hugging the coasts of Labrador and the Eastern States, and bearing over its bosom a dismal breath of fog and ice-cold vapour, is checked in its southward course by the genial current of the Gulf Stream. Those chill winds that sweep down the Mississippi Valley from the blizzard-haunted States of Dakota and Minnesota, bringing with them such noticeable fragments of a six months' frost as to be a very real menace to all semi-tropical fruits, are converted by the caloric power of the Gulf Stream into breezes which may be called rather bracing than boisterous, cool rather than cold. Again, the vicinity of the Gulf Stream causes that regular precipitation of rain which prevents Florida from becoming an arid barren in the summer, or an unnavigable swamp in the winter. The warm, water-laden winds which it generates assist in feeding the numerous rivers and lakes, and give sap to the luxuriant timber, sap which is eagerly imbibed by a large-leaved vegetation. In a word, this, the most interesting as it is the most important of oceanic rivers, encircles Florida with an ample grasp, and bestows upon that fortunately placed country the best of all natural gifts—extreme fertility.

Florida has been compared with Italy, but the comparison is odious—to the Floridian. Of course I refer solely to the physical character of the two countries, for Florida shares with the other States of the Union their hopeless blank of ancient history. It is true that the one is the most prominent peninsula of Europe and that the other holds the same position in the New World; it is also true that both cater for the remainder of their respective continents by the culture of fruit. It is true, too, that in both you find the long dark avenues of orange and lemon trees; and that the evening air brings the same delicious scent of the blossoming grove, whether you are lounging on the marble *balconi* of an Italian villa, or the yellow-pine verandah of a Florida bungalow; but here the parallel ceases. While Italy is shivering in those keen cold winds which plunge from the peaks of Monte Rosa or the Matterhorn, and whistle down the Saint Gothard and Simplon passes, Florida is basking in the genial breeze which its environment of tepid water ensures. When scorching siroccos send the unacclimatised flying from Rome, or Naples, to seek the more temperate delights of Saas or Zermatt, the Floridian rests content in the knowledge that, morning after morning, as punctual as the proverbial "clockwork," a refreshing breeze will arise and keep his house cool, and the trees in his grove in a pleasing state of tremor until late in the afternoon. Is not Italy compelled to irrigate? Florida has a rainfall so equally distributed throughout the seasons that irrigation is not required. Do snow-capped mountains make winter genial to the invalid? Florida has neither mountains nor snow. Is not Italy lapped round by an inland sea no warmer than the external ocean? Florida thrusts its length into the warm waters of the Gulf Stream, which, with a mean average of 77°, is the warmest current on the globe. You may compare Italy with the peninsula of Spain, or Greece, or even California; but you must contrast her with Florida.

Let me now take you on a flying trip through this State. You arrive, like the average visitor, at Jacksonville, the gateway city of the State. If you have come from New York you may have had a pleasant trip by steamer, or you may have preferred the Pullman car. At any rate, at Jacksonville you find yourself in Florida, and enveloped in an atmosphere of which the particles are hotels, invalids, business men, and those real estate agents, who have earned—and in many cases justly—the agnomen of "land shark." Jacksonville is the largest town in the State, though it is not the capital. Tallahassee is the legislative capital; but beyond the fact that tobacco has been very successfully grown in its vicinity, I need say nothing about Tallahassee. Jacksonville, however, is much more important. It is the chief port of Florida as well as the chief town. The export and import traffic is enormous, and increases by leaps and bounds every year.

Jacksonville is situated on the St. John's River, and it is from the river that most of the 100,000 visitors who annually winter in the State elect to get their first impressions of Florida. They have been whirled through the northern belt by night, perhaps, steeped in the oblivion of a Pullman sleeping-car, and have seen little or nothing of this part. What they have seen has not attracted. League after league, the lofty long-leaved pines have ranged behind each other in close and serried array; mile after mile the potato and strawberry patches, pear and peach orchards, and the comfortable homes of the "trucker"—that is, the man who grows vegetables and lesser fruits—crop up ever and again in the occasional breaks of the otherwise unbroken woods. This is the trucking belt of Florida. In all parts of the State early vegetables are grown for export, but in this section alone does it become the paramount industry. For Florida enjoys so genial a winter that she can ship her vegetables to the great northern markets as early as Bermuda—that is, in February and March. In April, when her supply is becoming exhausted, Georgia and South Carolina come into the market. Then follow North Carolina and Virginia, and with the accession of Maryland and New Jersey to the ranks, the prices fall so low that freight removes all profit. I have seen hogs fed with peaches because it would not pay to send the fruit even 20 miles! And yet, properly managed, trucking pays well. Only it demands so much more labour and attention, and, perhaps, because it has not the glamour which seems to environ the culture of the orange and the lemon, that most of the Englishmen who migrate to Florida elect to try their luck at the latter, and only fall back upon the former when their experience proves that all is not gold that glitters, that it is not always profitable to invest all one's money and labour in an orange grove.

And yet it is not in the least surprising if such a course should have proved irresistible. As one steams up the broad river of St. John's, and passes between the districts of Mandarin, Picolata, and Palatka, and finally emerges into the beautiful expanse of Lake George, the picture which the banks on either hand present is no common one. For mile after mile there spread the long avenues of orange trees, with their dark and glossy foliage, and their

> "Million million drops of gold
> In among the green."

Again and again we pass the pretty bungalow of the orange grower—a bungalow surmounted with deep gables, encircled with wide verandahs, and painted in a variety of colours, pink, red, white, blue, with an audacity which does not seem to jar. The dark pine woods have drawn away from the river, and fringe the horizon, and in their place the orange groves reign supreme. We have, in fact, reached the orange belt, *par excellence*.

Upon looking at the map on the wall, you will, I think, be at once struck by two features of this orange belt—by the importance of the St. John's and the Indian rivers in the east, and by the predominance of the lakes in the west. The belt, in fact, may be divided into two sections—fluvial and lacustrine—and for convenience sake, I will so deal with them. Both sections, however, possess the like advantage of being under the direct influence of considerable bodies of water, and we therefore find that their climate and general character are largely modified by this fact.

The river St. John's, which was called by the Seminoles the "Wee-la-ka," or the chain of lakes, rises in Lake Washington, the northern point of a large area of saw-grass prairie or swamp, and flowing through a dozen lakes of varying size, falls into the Atlantic Ocean, after a course of nearly 300 miles. For purposes of commerce and communication, and on account of the wide range of its basin, it is far the most important river in Florida. What the Watling-street was to Roman Britain, that the St. John's River is to modern Florida. It has always been the great highway of the State, and in spite of the rapid growth of the railway system, it still holds its ground as the most travelled track in the country. For a long distance it maintains an average breadth of three miles, and now and again it expands in some lake into a width of ten and even twenty miles. Upon its banks and the banks of its tributaries the most notable cities and the best cultivated areas are found. Within its basin the density of population is greatest, and the largest commercial enterprises have been undertaken, directly or indirectly, within its influence. Jacksonville, the port near its mouth, is the most important city in Florida; Palatta, near its junction with the Ocklawaha, is the great entrepôt of central Florida. De Land and Enterprise are flourishing towns; Sanford, which is at the head of the regular steam navigation of the river, is the converging point of several lines of railway, and Orlando, Orange City, and many other towns of importance all lie within its basin.

The St. John's River is not without its special attractions. Along its banks we meet with the dense growth of the red bay, magnolia, and cypress—trees which belong to the rich and humid soil of the "hammock" land. The water-oak and mahogany, the live-oak and the cypress—festooned with grey pendants of Spanish moss—grow to the water's edge; in the recesses and reaches of the river there lies an unbroken web of broad-leaved water-lilies upon the surface of the water; and as we steam along, the denizens of this highway take flight before us—blue cranes and white cranes, herons and turkeys, duck and snipe. Ever and again the alligator raises his snout above the water and blinks a sort of greedy welcome to us, or if he be lying like some dead branch upon the shore, lazily wags his tail by way of recognition.

Very different is the Indian River—so called. Properly, however, it is a lagoon of the Atlantic, and only separated from that ocean by those long stretches of coraline reefs which form for the geologist one of the most interesting features of the State. The Indian River is salt and tidal, and it is the home of an immense quantity and variety of game. Duck of all kinds—even the precious "canvas-back"—are common in this district, and the black or "raft" duck gather in their thousands and float down with the tide in solid phalanx, looking at a distance like some huge lumber raft—from which fact, indeed, they gain their name. Curlew and snipe, turkey and plover, are common objects of this country, and in the unsettled parts wild-cat, panther, and even bear may be hunted or avoided, according as you decide whether discretion or valour be the better part.

And yet the Indian River is famous for an orange which I believe to be the finest orange in the world. The Indian River orange is indeed a delectable fruit, the like of which Europe has not yet produced. Large and juicy, with the most exquisite taste, it might well be regarded as a worthy representative of the golden fruit which tempted the fair Atalanta to surrender her "running championship" and her state of single blessedness at one and the same time!

Curiously enough, the Indian River orange area is very restricted. It is confined to a belt never more than three miles wide, which runs along its western shore. In this narrow strip we find the homes of the orange growers of the district. There are few roads, for the river supplies all necessary means of communication. Buggies and waggons are almost unknown; boats and shallow-draught schooners are the favourite vehicles. Your fence is the waterside, your entrance-gate a jetty. The growing settlement is, in fact, Venice in the rough.

I now turn to the western half of the orange belt, which, as I said just now, is dominated by lakes. There are nearly two thousand lakes and lakelets in Florida, and the majority of them may be found here. They are very beautiful. The water is clear, and in many cases quite drinkable. The shores are wooded and often steep; but the lofty pine and the gigantic cypress are no longer the chief features of Florida lake scenery. The English settler shares with his American cousin a desire for a "lake-front," and, as a consequence, orange and lemon groves are found, in ever-increasing frequency, sloping towards the gleaming water of the lakes. Amid such pleasant surroundings the Englishman builds his castle, and a very comfortable sort of castle he makes of it. And what is perhaps best of all is the fact that our countrymen are steadily increasing in numbers and prosperity throughout this lake region of the orange belt.

Before passing to the portion of this paper which deals more closely with the English and the conditions under which we find them settled in Florida, I should like to quote from an article of mine which appeared in *Murray's Magazine*, an account of one of the typical features of the scenery of this southern State :—

"It forms one of the most desolate scenes I have ever beheld. I have gazed on the black rocks of St. Paul's, standing almost alone in the Indian Ocean; upon the repellant rufous hills of St. Helena; the salt marshes of the delta of the Godavery; the cruel solitude of Cape Agulhas—but I do not think I have ever seen anything so dismal, so desolate, as the cypress swamps of Florida. You enter them almost without warning; you hold your breath, as it were, while going through them, and the feeling of relief on leaving them is only less strong than the strangely morbid attraction they have for you, and which makes you visit them again and again. The white-barked cypresses stand overhead, reaching to a great height, and spreading their limbs widely round, and yet there is not a leaf, not a single green leaf to be seen. From bough and branch and twig there hang long tails and festoons of Spanish moss, an air-fed plant, grey in colour, and looking for all the world like the dishevelled tresses of an aged woman. Everywhere you look these sad grey hairs are either hanging listlessly, or swaying mournfully in the breeze. The water, which is often four or five feet deep, even in the paths, if paths they can be called, which are selected by your guide, is coloured a dark reddish brown by the quantity of tannin exhaled by the spongy mass of vegetation which everywhere underlies it. As you ride slowly through this dismal scene in Indian file, as the horse slowly forges ahead, the water washes up to your stirrups, and a sharp eye has to be kept unless, by a momentary departure from the narrow track you cannot see, you are to get a ducking. This dark, muddy water, silent and motionless, save where your party is churning it into something like frothy beer, is made even more dismal by its perfect reflections of the ghostly desolation overhead. It reproduces with startling vividnesss the long white trunks of the cypress trees, and the tangled grey hairs of the Spanish moss. Now and again the harsh piping cry of some lonely water bird accentuates the stillness; here and there the deadly mocassin coils about the spreading roots, black and grimy with the stagnant water, and adds by its very movement to the uncanny, the desperate desolation of it all. Such is a cypress swamp in Florida. None who visit this favoured peninsula should omit a ride through the labyrinths of its gloomiest feature."

Hundreds—yes, and thousands—of Englishmen have "gone west" as far as New York, and there turned their steps toward that "New South," of which the most unique as well as most progressive State is Florida. For them, the snowy charms of Manitoba or Alberta, the blizzards of Iowa and Minnesota, the mining towns of Idaho and Colorado, the prairie farms of Kansas, and the trackless ranches of New Mexico, have had no alluring spell. They have been attracted, rather, by the genial climate, the golden harvest and the promise of gain which the State of Florida holds out to them. They have heard of quaint old Spanish towns, romantic river scenery, and lakes as beautiful as they are numerous; they have heard of the magnolias, gardenias, and wild roses, which flourish amid the pine forests even as the green bay tree; of the big cypress swamps, where the alligator stirs the muddy water, and mosquito pervades the still malarious air; of the countless groves of orange trees, with their fragrant blossoms, dark glossy leaves, and glorious golden fruit; they have heard of all these, and much more besides, and nothing will satisfy them but a visit to this reputed land of flowers. They come to see, they remain to settle.

While sketching in the merest outline the character of the State and English settlement in it, I may as well say that in this paper I shall put light and shade together. Because I would point out the advantages, none the less shall I draw attention to the disadvantages which the Englishman encounters in his life in Florida. Both Florida and the English have suffered much from the bright pictures which have been painted of the conditions of life in this part of the world. There has been no shade to these gaudy views—no neutral tints nor half-tones — in short, the imagination of the unscrupulous agent has ramped in the fields of fiction, more free than any child of the boundless plain, and produced a kaleidoscopic romance not unworthy the admiration and credulity of an Oriental audience.

The first thing which strikes an Englishman when he reaches Florida is the sand. The soil appears—I say "appears," for its chemical composition proves it to contain something very different and far better—to be nothing but sand, in some parts grey, in others almost white. How, he naturally reasons, can all these fruits and flowers multiply and wax abundantly on such a soil? He arrives in the northern part of the State, where the oranges and magnolias, of which he has read so much, are rare, and he begins to smell a fraud. He almost sympathises with the Walrus and the Carpenter, and feels that he, too, could weep like anything to see such quantities of sand. But if he has come south by rail, has he not seen as he was jerked—the southern railroads are shockingly rough—through North and South Carolina and Georgia that those famous tobacco and cotton-raising States have also this sandy soil? If he has lingered in Charleston or Savannah, did he not kick up sand in a miniature cloud about him as he crossed the streets? And if he knew more of the Atlantic States, he would remember that from New England to Florida there stretches an almost unbroken seam of this loose sandy soil; that Martha's Vineyard, Cape Cod, and the coasts of Rhode Island and Connecticut are but little more than sand-dunes; that Long Island itself is composed of the same material, and that from Sandy Hook to Delaware Bay is a complete series of shifting sands. And he will soon learn that the well-known fertility of these Northern States is enhanced five-fold in Florida by the moderating influences of the genial climate, which knows nothing of a four-months' frost or of a two-days' blizzard.

Whether the Englishman arrives in the northern part of Florida by rail, or coming by steamer from New York, begin his contact with the State at Jacksonville, it is quite on the cards that his first feelings will be of chagrin and disappointment. The narrow northern belt of the State is devoted to the production of pears and peaches, and all manner of vegetables for the early markets. The uncleared country is wholly given over to monotonous leagues of pine forests, with little or no relief of underwood. Here and there fine orange groves are met with, but the orange belt proper is further south. The magnolias, the cabbage-palms, palmettoes, and all the tangled profusion and novel charms of a sub-tropical vegetation are not here; they are awaiting the traveller a hundred miles south, and he will probably be dissatisfied until he has ocular evidence of their existence.

Westward and southward of Lake George nine-tenths of the English are settled. Along the shores and in the neighbourhood of Lakes Harris, Griffin, and Weir, the healthy highlands between Lake Apopka and the upper reaches of the Withlacoochee River, eastward of the same lake even to the Indian River, a lagoon on the Atlantic Coast; on the low-lying lands in the neighbourhood of the Tahopekaliga and Kissimmee Lakes, as far south as Fort Meade and even trending on the great cattle-ranches that lie between Tampa Bay and Lake Okeechobee, you will find hundreds, yes, thousands of our fellow-countrymen engaged in solving the problem of existence with more or less success. The vast majority are growing oranges and lemons; the small, but ever increasing minority, vegetable growing, or "trucking" as it is called; sugar planting in the Kissimmee region, and dairy-farming in the neighbourhood of towns and favoured resorts. Many have failed in Florida, but more have succeeded. Given the necessary capital (or, in lieu, a greatly extended non-paying period), the necessary knowledge, and the necessary persistent industry — this is absolutely a *sine quâ non*—the Englishman in Florida has himself to thank if he does not achieve a distinct success. In all the cases of failure which have come under my personal observation, one or other or a combination of these three cardinal requirements has been neglected or ignored.

For what is the life which our countrymen lead in Florida? Simply this. The life which the constant, but by no means laborious, care of some hundreds — perhaps thousands — of fruit trees would impose in a sub-tropical climate, modified in an unusual degree by marine influences. A life in which none of the heavy labour of the farmer in the northern and middle States of the Union finds a place; a life where the blizzard, the months of frost and snow, the terrible cyclone, the excessive toil of the short northern summers are all unknown; a life which is compatible with ease and enjoyment, into which the ameliorations of civilisation penetrate naturally, and last, though by no means least, a life which is shared by thousands of our own folk.

English migration to Florida is of a distinctly high social type. The younger sons of what have been called "the classes" — young fellows who have plenty of tough muscle and English virility in them, albeit they have fallen ignobly before the test which various examinations, military chiefly, have applied to them; light-hearted youngsters who gravitate naturally from the classic forms of some public school to an unconventional life in a new country, and who are more fitted, by the force of heredity, or what you will, to handle a gun or back a horse than drive a quill at an office desk, even though it be situated in Whitehall—these are the men one meets in such numbers in Florida, and who are to a great extent justifying their selection of the life. But there are others, who are none the less important because they are fewer in number. Often and often as you ride from township to township, you come upon a charming home, situated, perhaps, on a lake, surrounded to a certainty by a flourishing grove, and with all the appointments of a well cared for estate. As you draw rein at the entrance-gate, a middle-aged man, who is possibly grey, and whom by his genial manner, light, easy clothes, and firm, assured carriage you at once "spot" as an Englishman, passes out of the shade of his verandah, and comes down the drive to welcome you. He calls a coloured groom to take your horse, and he leads you inside his bungalow. Here you find refinement combined with comfort on every hand. Articles of taste and natty contrivances to make existence more easy, jostle side by side. For a moment you wonder, but when you are introduced to an English lady—whom your experience in many lands and among many peoples has long since told you is an incomparable being—and she introduces you, in turn, to a bevy of charming children, your wonder ceases. For this is an English home in Florida.

These people are comparatively newcomers. Why have they come? I will tell you. In many cases this genial Englishman has been forcibly retired from the army or navy of his country, after giving his best years to its service. In the maturity of manhood, and the ripeness of experience, the paternal Government of England has said to him, much as the Yankee farmer says to his horse as he climbs into his buggy, "Git!" Willy-nilly, he has got! Or he may have had reverses in business; or, as a gentleman farmer in England, failed to reconcile his annual balance with his views of prosperity. In any case he is a man of superior breeding and of good antecedents. He is in most cases possessed of that fair amount of capital with which such wonders can be worked in a new country. He is a valuable addition to any community. Those personal inconveniences which a recent civilisation usually implies, and which drive so many of the younger men away, have but little effect on him. He knows that his ability to succeed in a new sphere is in inverse proportion to his age, and he is not to be allured away after some new fad, as so many of the youngsters are. He has come to Florida, he has come to stay. Homes like his more often than not attract young English bachelors to settle in the neighbourhood, and provide ballast for the little society. Men who, it is conceivable to suppose, might otherwise roughen into the rude but vigorous simplicity of the pioneer, recall the more wholesome of the *convenances* of the old country, and add in the evening, as a corollary to the work of the day, the refining indulgence of music—and morals! The married middle-aged Englishman is, I repeat, a great success in Florida, and his home is a feature which the wildest young settler would not eradicate.

Life in Florida is so different from that which is led in other States of the Union; so different, indeed, from life in any of our colonies, that it calls for some description at my hands. In the first place, it should be remembered that the fruit-grower's occupation differs widely from the farmer's. The heavy laborious toil which the farmer is compelled to undergo, whether he live in England or Canada, Minnesota or New Zealand, finds no place in the life of the Florida fruit-grower. The long lines of orange and lemon trees which radiate in all directions from the bungalow demand of him but slight toil in proportion to the returns they make. For about a third of the year the soil of the grove requires frequent ploughing and harrowing, so as to admit air and moisture to the lower stratum. But the sandy soil is so light, and the implements used are so small and handy, that there is no real labour involved. Moreover, the deep-furrow ploughing of the farmer is unknown in Florida. It would be fatal to the trees, for the members of the *citrus* family shoot out their roots horizontally at some six inches below the surface, and if the ploughshare or the harrow-teeth were to penetrate to this depth, the roots would be scarred or severed, and the tree more or less permanently injured. The plough, in fact, is so light that a pony can draw it, and the labour so moderate that a lad can sustain it without fatigue.

Between the periods of cultivation and harvest there intervenes one of rest. The vegetable as well as the animal world cannot be always at work. The soil must be allowed a time of "fallow," so that the trees may be able to gather strength for that concentration which results in production. The man who messes and muddles with his trees up to the very time of harvest is rewarded for his pains by loss of gains. To this period ensues the pleasantest of the three seasons of the agricultural, or, if you prefer it, arboricultural year. All through the charming winter days, which are bright with unclouded skies, and exhilarating with the buoyant air, the work of getting in the crop goes on. Throughout November, December, and January the great golden globes of fruit are being carefully clipped from the branches, wrapped in tissue paper, and packed in boxes, and then dispatched to those distant markets in the north where the demand for the luscious fruit is always far ahead of the supply.

A word about this question of demand and supply, for I have often been asked by Englishmen over here if the orange business is not being overdone in Florida. Starting with the statement that the Americans are the greatest fruit-eating people of the civilised world—everybody eating one or more kinds of fruit at every meal and at all possible opportunities between whiles—I would go on and say that the United States at present import about 700,000,000 of oranges from Europe. In a country where protection prevails it is obvious that every inducement exists for native producers to wipe off this item from the Customs' receipts. Where, then, shall we look for these native producers? I reply, only in Florida and California, pointing out in the same breath that only a very small section of California is fit for the culture of oranges, and that her winter, which is the season of maturity and harvest, differs from Florida's in having both wet and cold together, and in being, therefore, a constant menace to the success of the orange grower. In fact, it is the salvation of Florida that winter is her dry season, and that almost daily through her long summer heavy refreshing rains should fall. I do not suppose that the orange crop of Florida will ever exceed the consumption of the States. Should that happen, however, the excess can be safely exported, for I have no hesitation in saying that, for size and delicacy of flavour, the Florida orange, though you search the wide world over, has no equal.

Englishmen settle in Florida, either as members of one of the so-called "colonies," or independently, as isolated settlers. Both methods have their respective advantages and disadvantages, but perhaps the colonies have gained—and lost—more reputation from the fact that they are represented in England by so many "agents." Emigration agents—as we know too well—are more often a hindrance than a help. Usually they are personally ignorant of the country or colony they "boom," and there are not wanting those who, to their crass ignorance, add the ready recklessness of the rogue. There are exceptions, of course—notable exceptions—but they can readily be counted on the fingers of one hand. And here I may add a word of caution. Incredible as it may seem, I know it to be a fact that many people actually buy land in Florida without ever having seen an acre of it, without moving out of London. They have not even seen a man who has seen the land! The agent recommends it; of course he does, he has to live. The owner recommends it; of course he does, he wants to get rid of it. Now mark this—all Florida land is surveyed and mapped irrespective of lakes and swamps, and when a section is bought the water included in it helps to swell the total acreage. In the map the purchaser sees no indication of either, and buys, as he of course imagines, *terra firma*. I would therefore mention that I have known men arrive in this State already "land" owners, but on reaching their much-talked of—and thought of—estate they have found they have purchased a ghostly swamp with a few acres of wet prairie attached, or the noble bosom of a gleaming lake with a hundred yards or so of shore. Now, a lake is all very well, but it is not generally suitable for orange-trees, and is altogether an improper basis for the foundations of your house. The first person blamed is of course the agent. It is not his fault, for the maps are so misleading that he may be just as ignorant as the purchaser himself. The man who is in fault is the idiotic purchaser. One should never buy land in Florida without having first walked over every acre of it. For the soils are so different and are so mixed up that in a 40-acre section all the chief soils of Florida are often found, and consequently a man cannot know the nature of a section without examining it minutely.

The English "colonies" or settlements in Florida have not been an invariable success, and the reason is not difficult to find. As a rule they have been largely composed of young fellows but recently emancipated from school or college, who, it may seem curiously, have formed no settled habit of work. That opportunity for co-operation which is open to the members of a colony has generally appeared to them in the guise of sport alone, and numbers of young men who have come out with the best of all possible intentions, find it not only convenient but customary to drop them upon arrival in the colony. They have not the stamina to persevere; too frequently they have not the will. Again, these colonies are usually situated some distance from a large town, and there is, therefore, no special incentive to the colonists to produce such vegetables and lesser fruits as are always on demand in large centres; consequently, they devote themselves to oranges. Now it cannot be said too often, for there is much misapprehension about this subject, that a man who devotes himself entirely to orange or lemon culture must have capital, and a good deal of it too. I would advise no one who contemplates growing oranges for a livelihood to embark on that course on less than £2,000. For either a small bearing grove must be bought, or one that is more or less remote from that very profitable condition. In the one case nearly the whole of your money will be required for purchase, and in the other the balance will be required for living expenses till the grove pays. Applying these facts to the case of many young colonists, I find that a large number of them have not command of that amount of capital, that the majority of that number have no hope of ever having such an amount, and that a big minority is wholly composed of what are called "remittance men," that is to say, individuals who depend for the sinews for war on regular, and I might say, irregular supplies from home. No wonder is it, then, that the financial condition of the average English colony is the reverse of satisfactory, and that those members of it who see their hopes dipping down over the horizon seek consolation in such diversions as sport can afford.

These English colonies are popular, and there are several good reasons why they should be—indeed, there is no real reason why they should not be successful as well. There is congenial companionship to be found in them, and if the new arrival act up to his good intentions, and the sound and undeniable adage "business is business," he will not find it difficult to discover a kindred spirit among the older members. Then again, the colony usually means a good club, where the best of the home papers and magazines are to be found, not to speak of billiards, concerts, theatricals, and such other lawful delights as link the community to civilised life. In the colony, the new comer will see exemplified all gradations of success and failure, and he will be singularly blind to his own interests who does not learn from these examples what to avoid. The materials for co-operation and that unity which is strength lie scattered round him, and he has himself only to thank if he chooses to combine for folly rather than for mutual profit and security. Above all, the colony affords him society so good that, with the exception of India—and that is always an exceptional country — I defy the travelled Englishman (whose *confrère* I am) to point out another spot in any of the newer countries of the world where the immigration is of so high a character, and the social standing of the colonists so superior. Charming English ladies preside over no less charming English homes in Florida; their husbands are without exception men of good birth and breeding; and the gaieties and relaxations of the small communities, dotted over a large portion of the State, are the counterpart, shorn of conventionality, of the way we amuse ourselves over here. It is no social ostracism to go to Florida; you change your sky but not your manners, and in the colonies you will be able to sport that tempered Jingoism which is common to nearly all Englishmen dwelling in foreign countries, without having to consider whether you are unduly ruffling the feathers of that mightily susceptible bird—the American Eagle.

With these and many other advantages accruing to the colonies, it may surprise some to hear that a very large number of Englishmen eschew these communities, and become, as far as their countrymen are concerned, isolated settlers. Yet this is so very much the case that the majority of the Englishmen settled in Florida have pitched their tents here or there, as the fancy willed or the judgment dictated. A stranger among strangers, the Englishman so situated generally succeeds. The Americans around him mean business, and nothing short of business will the Englishman mean too. The tenacious spirit which is within him will make him early show fight and long persist. I do not say that he is not actuated by worthier motives, but from personal observation I am confident that an environment of Yankee settlers has an excellent effect on the average Englishman. Without parting with his insularity, which is certainly not likely if Jonathan or his continent be at hand, he yet imbibes, consciously or unconsciously, a habit of being practical "in thought, word, and deed." This habit stands him in such stead that there can be no moral doubt, though we have not the material evidence, that the percentage of failures among members of the English colonies is far higher than among the isolated settlers. I should add that if the latter are near large towns or tourist centres, they frequently make handsome incomes by growing vegetables and the lesser fruits. This "trucking," as it is called, requires but a small capital—say £500, or even less—and may be embarked on in a short time after arriving in the country. The returns are rapid and frequent, the profits handsome.

Many people naturally ask the question, what can I get for such and such an outlay? To reply with accuracy is almost impossible, so much depends on the personal equation, the grower himself. Then, again, the quality of the soil, and, if a made grove has been bought, the previous care and skill with which the trees have been cultivated, are most important considerations. Distance from market and means of transport, the quality of orange grown, and the state of the market at selling time, are other matters which influence profits. But I shall be able to make pretty clear the value of an orange grove if I give a brief description of the returns made by one of which I have personal knowledge, and which is of a distinctly average type.

A friend of mine bought this grove a year or so ago, giving £2,000 for it. The property consisted of forty acres, a quarter of a section, and was distributed thus:—Five acres of ten-year old trees, planted sixty to the acre; ten acres of trees varying from four to seven years old, also planted sixty to the acre; and twenty-three acres of uncleared pine land. The remaining two acres were occupied by the bungalow, cook-house, stable, hen-house, garden, and short drive. On these two acres many of the pine trees had been left, and between them guava bushes, bananas, gardenias, and other useful and ornamental plants gave both pleasure and shade. The first season after buying, the five-acre grove of ten-year old trees gave an average of 500 oranges a tree. These he sold on the tree to the commission agent at one cent. a-piece—that is, each of the 300 trees averaged £1 a-piece. He would have got more for his oranges had he sent them to New York, but at the same time the risk would have been greater. By far the best plan at present is to sell the fruit on the tree, and so avoid the cost and labour of picking, packing, and freight. The ten acres of variously aged, but chiefly young, trees brought in about £100. His gross receipts, therefore, this first season amounted to £400. Against this must be set cost of living for self and wife, £150; labour and cultivation, £60; repairs, improvements, &c., £30; various expenses, £20; personal expenses, £25—total, £285. That is to say, after the first year's expenditure had all been reckoned up, there yet remained a balance of £115.

There are two items here requiring a little explanation. The living expenses may seem small to us over here, but when it is remembered that fowls, vegetables, and fruits are all flourishing upon your own property, that fish abound in every lake and stream in Florida, that turkeys and quail are numerous throughout most sections of the orange belt, and in many parts can be shot without hunting for them, the moderation of this item is explained. Indeed, in this particular case the living was first-class—neither stint of quantity or variety. The other item is that of labour. My friend employed a negro who acted as cook and "general man" on the grove. Only very occasionally had he to hire other help. Now, when we recollect that this grove will go on increasing in value at a great rate—almost doubling its crop every three years for some time—and that my friend bought it for £2,000, and anybody can go and do the same to-day or to-morrow, it will be seen that orange-growing in Florida holds out undoubted attractions to those of us who want to get out of this overcrowded country.

Before closing these remarks on the position and prospects of the English in Florida, I should like to reassure some of those who may be wishing to migrate thither, but are fearful of the climate. And I may here say, as adding value to all what I have said, that I have no material interests whatever in the State, that if I am "booming" Florida at all, it is because I am convinced, from personal knowledge and observation, that it holds out special attractions to a large number of my countrymen who would find in no other field of emigration so congenial a life, or so suitable an occupation. Particularly would I point out to men of some capital and mature years that the conditions of orange and lemon culture in Florida are such as prove in no way disagreeable to those who, by habit and taste, are not fit for roughing it on the western plains or in the backwoods. The labour is essentially light, the life essentially pleasant.

The only time of the year in Florida which is not healthy is the short autumn of September and October, during which heavy and continuous rains, together with malaria, chills and fevers, and dengue fever prevail. This season will find out those who have been foolish enough to settle on hammock land or in the near vicinity of swamp. The majority of Englishmen, however, have pitched their tents on dry pine-land, and it is a curious fact that the more careless American suffers far more from the ills of this autumn season. Given reasonable care and regard for the ordinary precautions which suggest themselves at once to the experienced or the thoughtful individual, there is not the slightest reason why anything more than occasional discomfort or inconvenience should be felt during the Florida autumn.

On the other hand, both summer and winter are perfectly healthy. The summer, which is long, lasting as it does from April to the end of August, is modified by the splendid breezes which regularly blow throughout the hottest hours of the day. Moreover, few summer days slip by without there falling a short but heavy shower of rain in the afternoon, refreshing the drooping vegetation and cooling the air. The evenings and nights of this season are perfectly delicious, and the English are not slow to take advantage of this fact. The social gaiety which obtains after the work of the day is done is not by any means the least attraction to the life. The length of the summer is of course somewhat trying at first to the man who has hardly known in our capricious climate what summer is, but he will soon "shake down," and learn to regard the season in the same light as the majority of his neighbours, that is, as "a good time."

The winter requires but little notice. From sixty to eighty thousand 'cute Yankees would never travel all the way to Florida if there was not something to be gained by it. Florida would not have hundreds of palatial hotels, many of them accommodating over a thousand guests apiece, if these same Yankees were to go away after their first visit with the resolve never to return. No, winter in Florida is just about as perfect as we can expect things mundane to be. It is the dry season, the cloudless season, the season of bright bracing weather. The cloudless orange groves, whose glossy leaves shimmer in the sun, are ablaze with their golden harvest; the orange growers are but awaiting a loud outcry from the northern markets to gather in of their abundance, a process which continues all through the winter months; the larger lakes and rivers are churned and ploughed by numberless steamers bearing living as well as dead freight; the turkeys and quails are at their fattest, and it is no exertion to go in pursuit of them; the air has a sparkle in it that braces people to enjoyment and exercise; the leagues and leagues of tall pines make long bars of alternate shadow and sunshine upon the magnolias, gardenias, and roses which blossom below their branches. Before and after the actual harvesting of the all-important orange crop there is nothing for the settlers to do, and, as a consequence, "horseback pic-nics" of some twenty or thirty strong, or boating excursions upon the broad waters of the countless lakes, become the order of the day. The vast incursion of northern tourists makes business brisk, and the many industries which cater for them are coining dollars; and, in a word, the physical enjoyments and pecuniary advantages which Florida holds out to those who can grasp them are at their height during this delightful winter season, focussed to a pitch of startling brilliance.

Have I not sketched a life which is worth the living? Have I not pointed out a channel for the overflow of those energies which this dear old country is all too small to contain? But do not rely on me—go and see for yourselves.

DISCUSSION.

The Chairman said there was not much room for discussion on a paper of this character, but he would venture to call attention to certain small omissions which Mr. Montefiore had made; they were very small certainly, but sometimes they were important. Mr. Montefiore had left out the insects, but he did not think they could have left him out when he was in Florida. In the first place there were mosquitos there, and he had been told by some of his American friends, who had been in Florida, that on one occasion, when camping out near the lakes, when they lit a fire, the flames attracted such swarms of mosquitoes that they put the fire out. Mention had been made of the sand, but nothing had been said about the sandflies, which were a great pest. No doubt, as civilisation advanced, the state of the country would be much improved from what it was when he was there many years ago. At that time their nearest neighbours were generally alligators, and those farthest off were alligators also, and they had to keep a pretty sharp look-out for them. The photographs exhibited had shown what great advances had been made, and he believed a great part of that advance had been made by the English colonists. Of recent years there had been a great improvement in the climate of Florida, for at the time he was speaking of, anyone who went there was always careful to be well provided with quinine, as a remedy for fever. The pine forests where the English had settled were a great preventive of malaria, and no doubt they would hear before long of the *Eucalpyius* being introduced, which would be of great service in improving the swampy ground.

Mr. J. FILDES said he had been much interested in this paper, and felt a wish to go to Florida. Fruit growing had been one of his chief occupations, and he should like to know what fruits would be likely to flourish in the orange belt; probably apples would not, and he presumed the vine would be a little out of its latitude also. He should also like to know what fish were found in the lakes, and whether trout were included. There was a large fish which abounded on the coast, called the tarpon, which he had never heard of elsewhere, which Mr. Montefiore had probably had some experience of.

Mr. S. S. BROMHEAD asked if there were not some danger of volcanic action in Florida; he had an impression that the country was rather liable to seismic disturbance. A great deal had been said about the Florida orange, but it was doubtful whether it would bear comparison with those which came from St. Michael's and other places to this country. He had more than once tasted Florida oranges, and though they were large and juicy, he found them rather tasteless. But perhaps that might arise from their being gathered too early, in order to be able to stand the voyage. He should also like to know if the vine would flourish there.

Mr. J. TRAILL-TAYLOR said it was impossible to treat thoroughly of Florida in a single paper, but one point in particular was conspicuous by its absence, and that was the cause of the great exuberance of vegetation. There was an apparently dry and barren sand, and yet almost anything would grow. The cause of this fertility had been discovered within the ast few weeks in the shape of enormous beds of phosphate of lime, which he held were not confined to any one place, but were spread about near Talahassee, up beyond Tampa, and in many other places. The boom seemed to have come at last, and the place was being overrun with speculators and searchers after phosphates, He had some interest in Florida, in the Lake Country, which he was glad to hear was the best part, having one or two orange groves on one of the best lakes there. With regard to fish, the very last night he was there he went out with his son and a companion to try and shoot an alligator which was known to be in Lake Harris, as it was now called, though the native name, Astatula, was much prettier. The alligator got away, though he was shot next day, and measured about 13 feet; but with a small casting net they captured forty-one fish in a very short time. These were mainly bream, or of that character. There were also gar fish, which were very much larger, four or five feet in length, but this was not the formidable gar fish of the Texas lakes. Cat fish were also plentiful, which he found very good eating, and having set the example other people ate them also, though before they had been neglected. One great drawback to that particular part of Florida was the high charge for railway travelling; no doubt it would be reduced by and bye, but at present it was very burdensome.

Mr. COOK said he had received a box of oranges from his brother in Florida, and he could endorse all that Mr. Montefiore had said about them. In a letter from his brother, a few days ago, reference was made to the discovery of the phosphates, which it was thought was going to work wonders; and his brother always spoke in very glowing terms of his mode of life out there.

Mr. FILDES said he could understand that deposits of phosphates might be found in certain patches, but he questioned whether that was the main cause of the general fertility of the soil.

Mr. MONTEFIORE said that there were a large number of fruits grown in Florida, but many as yet simply as experiments. Pears, peaches, pineapples, bananas, oranges, and lemons were all grown with profit. The question as to the fish in the lakes had been already answered; as to the tarpon or silver king, he could occupy a long time with tales of it, but the practical point was that it was not worth anything for eating, and was only pursued for sport. Some of these fish were 150 lbs. in weight, and would tow a boat along when hooked if the anchor was not down. He did not think there was any danger of volcanic action sweeping Florida away. American geologists were of opinion that there was a great submarine sea under the peninsula of probably considerable depth, and that in fact it was reared on a kind of arcade of coraline structure, and if so he thought that would act as a kind of protection against volcanic action. With regard to the quality of the oranges, he had already given his opinion; he thought they were unequalled. He had been to the Azores, but it was some time ago, and he did not remember eating oranges off the tree, as he had in Florida very often, with great satisfaction. The oranges sent over here were picked in an immature state, and were no doubt injured to some extent by the packing and the voyage; but he was quite certain that he had never eaten any which were sweeter or of more delicious flavour than these in Florida. In the northern belt, especially in the trucking district, the vine industry was being rapidly developed, and several experiments had been made in wine-making. In time, no doubt, they would make good wine, but what he had tasted was of a very amateur description, and he would rather not say anything about it. The vines grew very well; a friend of his constructed an arcade of trellis work from the outside gate up to the house, and planted vine-cuttings, and when he saw it two years afterwards the arcade was beautifully covered. As to the cause of the exuberant vegetation, he thought probably the presence of phosphates had some influence, but they were by no means the only cause. The two great requirements for luxuriant vegetation were heat and moisture. In Sumatra and Java, for instance, vegetation reached a degree of luxuriance probably unequalled on the face of the globe; those islands were right in the tropics, and surrounded by water. To a very large extent Florida was sub-tropical, and it was surrounded on three sides by the warmest ocean-current on the face of the earth, which did not vary more than seven degrees in the course of the year. Then the trade winds, which originally came warm from the equator, retained their heat by passing over the Gulf Stream, and he thought, therefore, that the fertility of the country might be attributed more to the warm moist winds than to the quality of the soil. He agreed with Mr. Taylor that it was a great pity the Seminole names had not been retained. One gentleman, out of pure devotion to his wife, changed the name of a very pretty lake, which had a pretty name too, to Lake Sarah Jane, which he thought was carrying conjugal affection to an extreme.

The CHAIRMAN then proposed a hearty vote of thanks to Mr. Montefiore, for his interesting and instructive paper, which was carried unanimously.

Correspondence.

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UTILISATION OF SLAG.

Mr. HENRY FAIJA writes, with reference to the communication which appeared from him in the *Journal* of the 21st inst., that the condensed form in which it, of necessity, appeared, made him seem to condemn slag cement entirely. Mr. Faija wishes it to be understood that though he condemned slag cement as a substitute for Portland cement, he acknowledged it as a cement of some value.

OCEAN PENNY POSTAGE.

Captain FAIRHOLME writes to correct the report of his remarks on Mr. Henniker Heaton's paper:—What he pointed out was that in no other country in the world, which has joined the Postal Union, does the Class B exist, which exists in this country, but that the postage in them for all Postal-Union countries is the normal 2½d. fee, whereas, in Great Britain, the countries have been divided into two classes, of which the A class is 2½d., and the B class 4d. and 5d., an anomaly and injustice which it is impossible to understand. As regards the German money order system also, he wishes to point out the following advantages:—A, wishing to remit money to B, purchases, at the post-office for 2d., a postal order card, to which a coupon is attached, which is intended to convey any message he may wish to send to B. After filling up the card with the necessary amounts, &c., he hands it, with the money, to the official, and pays for extra stamps in proportion to the amount to be forwarded. The postman brings the money and this card to B, who cuts off and retains the coupon (containing, probably, a renewed order for execution), and signs and returns to the postman the body of the card, and the transaction is then complete.

18, St. Dunstan's-hill, E.C.
February 22nd, 1890.

ORGANISATION OF SECONDARY AND TECHNICAL EDUCATION IN LONDON.

As an old member of your Society, and a reader of your weekly *Journal*, I perused with pleasure Professor Thompson's paper on "The Organisation of Secondary and Technical Education," but I feel compelled to express my astonishment at the remarks of Mr. Hooper, who took part in the discussion.

Mr. Hooper said that "he had been anxious to get a number of text-books prepared applicable to the industry (coach-building) with which he was connected, which should be thoroughly representative, and to that end he thought of having them prepared by one man and edited, revised, and criticised by others in different parts of the country."

Mr. Hooper then said that as a manager of a technical class he "sent a clever young Scotchman over to be trained in Paris; he spent some time there, became a distinguished student, and then, returning to this country, became a teacher, and had trained quite a body of teachers, who had spread similar classes all over the country."

These remarks are calculated to give rise to a belief that there are no text-books in existence, and that Mr. Hooper has done all the work in promoting the study of technical coach-building. It is unjust to the originators, teachers, and students of the successful classes in the provinces, where schools have been carried on, in several cases, during the past 30 years. I am thus compelled to correct this misrepresentation.

Mr. H. M. Holmes, of Derby, has, at his own expense during the last 30 years trained apprentices in mechanics applied to coach-building. Several of these apprentices are now foremen and managers in leading factories in London. Similar classes have been carried on in Newcastle, for about the same period, under my management.

In 1864, the Worshipful Company of Coachmakers expressed appreciation of the advantages of such classes, and offered valuable prizes to encourage the practice of drawing, and the production of prize essays in the different branches of coachbuilding.

Several of these essays have been published as text-books by Messrs. Kemp and Company, 46, Cannon-street, E.C., and by Messrs. Cooper and Company, 64, Long-acre, W.C. These firms have purchased the copyrights, and in justice to them their text-books should not be ignored.

Mr. George A. Thrupp was equally earnest in the movement, and his admirable "History of Coaches" is well-known to many readers. It forms one of the books approved and adopted by Sir Philip Magnus, the director of the City and Guilds of London Institute.

The classes in coachmaking were amongst the first technical classes in this country. Their success is attributable to the encouragement by the Coachmakers' Company, and the names of Mr. Joseph Peters, Mr. W. T. Thorn, Mr. J. F. Woodall, Mr. H. M. Holmes, Mr. G. A. Thrupp, and Mr. G. N. Hooper will always stand prominent as the promoters of that laudable scheme.

As a provincial coachmaker, I have always appreciated the action of the Coachmakers' Company in extending their competitions to the provinces. It has resulted in the production of valuable books and in a knowledge of the technicalities used, both in London and in provinces. This could never have been effected had the competition been confined to London.

Mr. Hooper's observations may have been intended to refer to London only and not to the provinces, from where most of the successful essays have emanated. Those books have been adopted on the recommendation of Mr. G. A. Thrupp as text-books to be used in the existing technical class, and for the information of your readers I append a list as an advertisement in your *Journal*.

Professor Thompson's ideas on a national system of technical education are correct. He says, "The instructors should be craftsmen accomplished in the technique of their respective subjects, and gifted with the power of teaching it and the principles that underlie it. The teaching must be live teaching, each pupil educating himself by working in the laboratary, or workshop, or studio under an instructor who has worked in his trade. Such teaching is worth more than all lectures and worth more than all books by the most encyclopædic of writers." Hence, text-books produced in the form of prize essays by specialists who have worked at their trade are the only ones of any real value. Those adopted by Sir Philip Magnus have been written and edited by men possessing a knowledge of the technical terms used in London and the provinces.

One of the greatest stumbling blocks to success are the absurd questions frequently put by examiners. I have urged upon Sir Philip Magnus the necessity for these questions being drawn up by two gentlemen, a London and a provincial expert, who understand the terms used in various parts of the country. Technical names vary in different localities, and in many cases students have failed because they did not understand the question.

Others have been plucked for faulty orthography, an evident injustice. Accuracy should be encouraged, but we must attend to methods of working and the outlines, proportions and perfection of our productions, rather than a grammatical answer to a question. Examiners should be selected for their practical knowledge rather than their scholarly attainments.

JOHN PHILIPSON.

Mr. GEORGE A. THRUPP writes:—The success of certain polytechnics in getting youths to study is unquestionable, and the non-success of the mechanics' institutes is also unquestionable. The day studies of the Science Department classes have attracted but a fraction of working men compared with the admirable and interesting building construction classes. But the polytechnic classes, founded upon the plan of the latter, have had a great success; they meet the wants and understandings of young workmen, and institutions such as these are capable of development in an upward direction. Meantime it has not been shown that the students from the polytechnics are not as well taught, and supplied with as good teachers, class-rooms, work-rooms, and sufficient laboratories, and further that these students do not pass examinations as creditably as the students of institutions where the studies are chiefly on dry science subjects. The polytechnics and evening recreation classes attract our youth to their walls, and then offer them opportunities of studying the principles—scientific, mechanical, and artistic—which underlie the exercise of their daily work, whether already entered upon or about to be entered upon, in a manner that suits and gratifies them. I was for some years one of the examiners for the City and Guilds Institute, and am sure that cramming to pass the examinations on the part of the teachers is not possible under the present system of teaching, whilst a system of teaching by text-books might lead to a cram system dependent upon the memory.

General Notes.

DECORATIVE PAINTING.—A travelling studentship of £50 is offered by the Painters' Company for the encouragement of the study of decorative painting.

The studentship is open to any competition by students between the age of 20 and 35 in any recognised school of art or other institution devoted to the study of applied art in any form, and situate within the limit of the larger metropolitan postal area. The rules for the competition can be obtained on application to the Clerk of the Painters' Company, Painters'-hall, Little Trinity-lane, London, E.C.

LEEDS INTERNATIONAL EXHIBITION.—An International Exhibition is announced to open at Leeds, early next May, and to remain open for six months. A special section, housing of the poor, will include models of apartments, both full-size and in miniature, for one, two, and more tenants, sanitary and other fittings, furniture, and models of dwellings suitable for tenants under the Guinness gift. Besides engineering, mining, electrical, and chemical sections, another will be devoted to hygiene, including sanitary appliances, lighting other than electric, heating and ventilation, water supply, and gymnasia. Other sections relate to clothing, domestic and labour-saving appliances, food, manufactures, and raw material, education, and the fine arts.

THE FORTH BRIDGE.—The number of *Engineering* for the current week is a special one devoted to a description of the Forth Bridge, the opening ceremony of which will take place on Tuesday, March 4th next. The description, which has been prepared with the co-operation of the engineers and contractors of the bridge, is of very unusual length, and very full in character, dealing with the history of the idea, the character and construction of every detail of the work, the method in which the difficulties incidental to a work of such magnitude was met, &c. Biographical notices of Sir John Fowler, Mr. Benjamin Baker, and others associated with the enterprise, are included. The illustrations eomprise about 160 engravings in the text, and 17 two-page plates. The publication of so full a record of this wonderful piece of engineering, immediately on its completion, and before its actual opening, is a remarkable instance of the promptitude of modern technical journalism, and is probably unique in its character. This number of *Engineering* appears even larger and more complete than the one giving the full account of the Paris Exhibition, published at the time of the opening last year.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

MARCH 5.—J. TRIPPLIN, "Recent Progress in British Watch and Clock Making." The ASTRONOMER-ROYAL, F.R.S., will preside.

MARCH 12.—SIR DOUGLAS GALTON, K.C.B., D.C.L., F.R.S., Vice-President of the Society, "The Chemin de Fer Glissant, or Sliding Railway." Sir FREDERICK BRAMWELL, Bart., D.C.L., F.R.S., will preside.

MARCH 19.—J. S. KELTIE, "Commercial Geography." SIR FREDERICK ABEL, C.B., D.C.L., F.R.S., will preside.

MARCH 26.—G. N. HOOPER, "Carriage Building and Street Traffic in England and France." COLONEL SIR NIGEL KINGSCOTE, K.C.B., will preside.

FOREIGN AND COLONIAL SECTION.

Tuesday afternoons, at Five o'clock:—

MARCH 18.—JAMES W. WELLS, M.Inst.C.E., "Brazil."

INDIAN SECTION.

Thursday afternoons, at Five o'clock:—

March 13.—W. R. ROBERTSON, "Agriculture and the State in India." SIR CHARLES TURNER, K.C.S.I., will preside.

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock:—

MARCH 11.—JAMES ORROCK, R.I., "The Claims of the British School of Painting to a thorough representation in the National Gallery." Sir JAMES D. LINTON, P.R.I., will preside.

[Pictures by illustrious English masters whose works are not included in the National Gallery will be exhibited by Mr. Orrock.]

MARCH 25.—W. J. LINTON, "Engraving in Wood, Old and New."

CANTOR LECTURES.

Monday evenings, at Eight o'clock:—

THOMAS BOLAS, F.C.S., "Stereotyping." Three Lectures.

LECTURE III.—MARCH 3.—Various Stereotype Methods.—Casting in plaster moulds. Survival of the method for casting from music type. The copper electrotype backed with soft metal. Casts in brass and the more refractory metals. Softer stereotypes—Celluloid, india-rubber, gelatinous compositions.

POPULAR LECTURES.

Saturday afternoons, at Three o'clock:—

Professor VIVIAN LEWES, "The Atmosphere." Four Lectures.

LECTURE I.—MARCH 8.—The physical history of the atmosphere, and how it was first discovered that it had weight. Its probable extent and the phenomena on which such calculations are based. The discovery and demonstration by Lavoisier of the composite character of the atmosphere. How the proportions in which oxygen and nitrogen are present in air can be determined. Air a mechanical mixture of the gases composing it, and not a chemical compound.

Lecture II.—March 15.—The preparation and properties of oxygen gas, the great supporter of life and combustion in the atmosphere. Nitrogen an inert gas which dilutes and tempers the action of the oxygen. The natural impurities always present in air. Water vapour and its importance to health and comfort. The traces of nitric acid and ammonia found in air, and the functions which they perform.

Lecture III.—March 22.—Carbon dioxide in the air. How it is formed, and why it should not be present in air in larger quantities than six parts in ten thousand. Respiration. The action of the heart and lungs, and the part played by the air in supporting life. Nature's laws for keeping the composition of the air constant. Plant life and diffusion of gases.

Lecture IV.—March 29.—Local impurities in air. Germs and the propagation of disease. Decay. Purification of the air by rain and oxidation. Ozone. The air of enclosed spaces, and the amount of fresh air required for health. Ventilation. The formation of air currents. Draughts. The effect of our methods of heating and lighting rooms upon health. Conclusion.

Additional Lectures.

Thursday evenings, at Eight o'clock:—

Lewis F. Day, "Design applied to Wood-Carving." Three Lectures.
May 1, 8, 15.

MEETINGS FOR THE ENSUING WEEK.

Monday, March 3...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Thomas Bolas, "Stereotyping." (Lecture III.)

Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.

Engineers, Westminster Town-hall, S.W., 7½ p.m. Mr. R. H. Tweddell, "The Application of Water-Pressure, to Machine Tools and Appliances."

British Architects, 9, Conduit-street, W., 8 p.m. Discussion on Mr. John Slater's paper, "Building Legislation."

Medical, 11, Chandos-street, W., 8½ p.m.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m. Rev. James Legge, "Chinese Chronology."

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. Henry Blackburn, "The Art of Popular Illustration."

Tuesday, March 4...Royal Institution, Albemarle-street, W., 3 p.m. Dr. G. J. Romanes, "The Post-Darwinian Period." (Lecture VII.)

Central Chamber of Agriculture (at the House of the Society of Arts), 11 a.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Mr. C. O. Burge, "The Hawkesbury Bridge, New South Wales." 2. Mr. F. T. G. Walton, "The Construction of the Dufferin Bridge over the Ganges at Benares." 3. Mr. G. E. W. Cruttwell, "The New Blackfriars Bridge on the London, Chatham and Dover Railway."

Pathological, 20, Hanover-square, W., 8½ p.m.

Biblical Archæology, 9, Conduit-street, W., 8 p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Mr. Henry Seebohm, "The Classification of Birds." 2. Mr. R. L. Pocock, "A Revision of the Genera of Scorpions of the Family *Buthidæ*, with Descriptions of some new South African Species." 3. Mr. T. D. A. Cockerell, "Some Galls from Colorado." 4. Mr. A. Thomson, "Report on the Insect house for 1889."

Wednesday, March 5...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. J. Tripplin, "Recent Progress in British Watch and Clock Making."

Entomological, 11, Chandos-street, W., 7 p.m. 1. Mr. C. J. Gahan, "New Longicornia from Africa and Madagascar." 2. Mr. J. J. Walker, "Notes on the Lepidoptera of the region of the Straits of Gibraltar." 3. Dr. D. Sharp, "Some Water Beetles from Ceylon." 4. Mr. E. Meyrick, "The Classification of the Pyralidina." 5. Captain H. J. Elwes, "A New Species of *Thymara*." 6. Mynheer P. C. T. Snellen, "A Catalogue of the Pyralidæ of Sikkim, collected by H. J. Elwes and the late Otto Möller."

Archæological Association, 32, Sackville-street, W., 8 p.m.

Obstetrical, 20, Hanover-square, W., 8 p.m.

Thursday, March 6...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Mr. D. Morris, "The Production of Seed in some varieties of the common Sugar Cane (*Saccharum officinarum*)." 2. Mr. Spencer Moore, "An Investigation into the True Nature of Callus." Part I.—The vegetable marrow and *Ballia callitricha*.

Chemical, Burlington-house, W., 8 p.m.

London Institution, Finsbury-circus, E.C., 6 p.m. Dr. B. W. Richardson, "The Birth of Great Inventions—the First Electrician."

Royal Institution, Albemarle-street, W., 3 p.m. Mr. F. Niecks, "The Early Developments of the Forms of Instrumental Music." With Musical Illustrations. (Lecture I.)

Camera Club, Bedford-street, Strand, W.C., 8 p.m. Mr. Andrew Pringle, "The Optical Lantern."

Archæological Institution, Oxford-mansions, Oxford-street, W., 4 p.m.

Ladies' Sanitary Association, 22, Berners-street, W., 3½ p.m. Mrs. Atkins, M.D., "Heredity."

Friday, March 7...United Service Inst., Whitehall-yard, S.W., 3 p.m. Surgeon-General J. A. Marston, "The Medical Service in Modern War."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Mr. Francis Gotch, "Electrical Relations of the Brain and Spinal Cord."

Geologists' Association, University College, W.C., 8 p.m. 1. Mr. B. B. Woodward, "The Pleistocene (non-marine) Mollusca of the London District." 2. Mr. W. J. Lewis Abbott, "Notes on some Pleistocene Sections, in and near London." 3. Mr. Wheelton Hind, "Note on a Curious Appearance produced by the Natural Bisection of some Spherical Concretions in a Yoredale Stone Quarry near Leek."

Physical, Science Schools, South Kensington, S.W., 3 p.m. Prof. S. P. Thompson, "Bertrand's Refractometer."

Saturday, March 8...Royal Institution, Albemarle-street, W., 3 p.m. Lord Rayleigh, "Electricity and Magnetism." (Lecture IV.)

Journal of the Society of Arts.

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FRIDAY, MARCH 7, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

THE ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal for 1890 early in May next. The medal has been awarded as follows in previous years :—

In 1864, to Sir Rowland Hill, K.C.B., F.R.S., "for his great services to Arts, Manufactures, and Commerce, in the creation of the penny postage, and for his other reforms in the postal system of this country, the benefits of which have, however, not been confined to this country, but have extended over the civilised world."

In 1865, to his Imperial Majesty, Napoleon III., "for distinguished merit in promoting, in many ways, by his personal exertions, the international progress of Arts, Manufactures, and Commerce, the proofs of which are afforded by his judicious patronage of Art, his enlightened commercial policy, and especially by the abolition of passports in favour of British subjects."

In 1866, to Michael Faraday, D.C.L., F.R.S., "for discoveries in electricity, magnetism, and chemistry, which in their relation to the industries of the world, have so largely promoted Arts, Manufactures, and Commerce."

In 1867, to Mr. (afterwards Sir) W. Fothergill Cooke and Professor (afterwards Sir) Charles Wheatstone, F.R.S., "in recognition of their joint labours in establishing the first electric telegraph."

In 1868, to Mr. (afterwards Sir) Joseph Whitworth, LL.D., F.R.S., "for the invention and manufacture of instruments of measure and uniform standards by which the production of machinery has been brought to a state of perfection hitherto unapproached, to the great advancement of Arts, Manufactures, and Commerce."

In 1869, to Baron Justus von Liebig, Associate of the Institute of France, For. Memb. R.S., Chevalier of the Legion of Honour, &c., "for his numerous valuable researches and writings, which have contributed most importantly to the development of food economy and agriculture, to the advancement of chemical science, and to the benefits derived from that science by Arts, Manufactures, and Commerce."

In 1870, to Vicomte Ferdinand de Lesseps, Member of the Institute of France, Hon. G.C.S.I., "for services rendered to Arts, Manufactures, and Commerce, by the realisation of the Suez Canal."

In 1871, to Mr. (afterwards Sir) Henry Cole, K.C.B., "for his important services in promoting Arts, Manufactures, and Commerce, especially in aiding the establishment and development of Science and Art, and the South Kensington Museum."

In 1872, to Mr. (now Sir) Henry Bessemer, F.R.S., "for the eminent services rendered by him to Arts, Manufactures, and Commerce, in developing the manufacture of steel."

In 1873, to Michael Eugène Chevreul, For. Memb. R.S., Member of the Institute of France, "for his chemical researches, especially in reference to saponification, dyeing, agriculture, and natural history, which for more than half a century have exercised a wide influence on the industrial arts of the world."

In 1874, to Mr. (afterwards Sir) C. W. Siemens, D.C.L., F.R.S., "for his researches in connection with the laws of heat, and the practical applications of them to furnaces used in the Arts; and for his improvement in the manufacture of iron; and generally for the services rendered by him in connection with economisation of fuel in its various applications to Manufactures and the Arts."

In 1875, to Michael Chevalier, "the distinguished French statesman, who, by his writings and persistent exertions, extending over many years, has rendered essential service in promoting Arts, Manufactures, and Commerce."

In 1876, to Sir George B. Airy, K.C.B., F.R.S., Astronomer Royal, "for eminent services rendered to Commerce by his researches in nautical astronomy and in magnetism, and by his improvements in the applications of the mariner's compass to the navigation of iron ships."

In 1877, to Jean Baptiste Dumas, For. Memb. R.S., Member of the Institute of France, "the distinguished chemist, whose researches have exercised a very material influence on the advancement of the Industrial Arts."

In 1878, to Sir Wm. G. Armstrong (now Lord Armstrong), C.B., D.C.L., F.R.S., "because of his distinction as an engineer and as a scientific man, and because by the development of the transmission of power—hydraulically—due to his constant efforts, extending over many years, the manufactures of this country have been greatly aided, and mechanical power beneficially substituted for most laborious and injurious labour."

In 1879, to Sir William Thomson, LL.D., D.C.L., F.R.S., "on account of the signal service rendered to Arts, Manufactures, and Commerce, by his electrical researches, especially with reference to the transmission of telegraphic messages over ocean cables."

In 1880, to James Prescott Joule, LL.D., D.C.L., F.R.S., "for having established, after most laborious research, the true relation between heat, electricity, and mechanical work, thus affording to the engineer a sure guide in the application of science to industrial pursuits."

In 1881, to August Wilhelm Hofmann, M.D., LL.D., F.R.S., Professor of Chemistry in the University of Berlin, "for eminent services rendered to the Industrial Arts by his investigations in organic chemistry, and for his successful labours in promoting the cultivation of chemical education and research in England."

In 1882, to Louis Pasteur, Member of the Institute of France, For. Memb. R.S., "for his researches in connection with fermentation, the preservation of wines, and the propagation of zymotic diseases in silk worms and domestic animals, whereby the arts of wine-making, silk production, and agriculture, have been greatly benefited."

In 1883, to Sir Joseph Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S., "for the eminent services which, as a botanist and scientific traveller, and a Director of the National Botanical Department, he has rendered to the Arts, Manufactures, and Commerce by promoting an accurate knowledge of the floras and economic vegetable products of the several colonies and dependencies of the Empire."

In 1884, to Captain James Buchanan Eads, "the distinguished American engineer, whose works have been of such great service in improving the water communication of North America, and have hereby rendered valuable aid to the commerce of the world."

In 1885, to Mr. (now Sir) Henry Doulton, "in recognition of the impulse given by him to the production of artistic pottery in this country."

In 1886, to Mr. Samuel Cunliffe Lister, "for the services he has rendered to the textile industries, especially by the substitution of mechanical wool combing for hand combing, and by the introduction and development of a new industry—the utilisation of waste silk."

In 1887, to HER MAJESTY THE QUEEN, "in commemoration of the progress of Arts, Manufactures, and Commerce throughout the Empire during the fifty years of her reign."

In 1888, to Professor Hermann Louis Helmholtz, "in recognition of the value of his researches in various branches of science and of their practical results upon music painting, and the useful arts."

In 1889, to Dr. John Percy, F.R.S., "for his achievements in promoting the Arts, Manufactures, and Commerce, through the world-wide influence which his researches and writings have had upon the progress of the science and practice of metallurgy."

The Council invite Members of the Society to forward to the Secretary, on or before the 19th of April, the names of such men of high distinction as they may think worthy of this honour.

CANTOR LECTURES.

In the third and final lecture of his course on "Stereotyping," Mr. BOLAS dealt with the various stereotyping methods of secondary importance. In reference to casting stereotypes in brass, he showed how asbestos millboard might be used as a mould. When wetted, it is pressed against the original, removed, dried at a heat bordering on dull redness, and when it and a similar piece of plain asbestos millboard are clamped in the usual stereotype casting-box, with a bent iron wire guage between them, the brass is poured in at the top. The asbestos millboard should be about 3-16ths of an inch thick, and in this case there is no need to warm the casting-box, the slow conducting quality of the asbestos preventing all chilling of the metal. In connection with auto-stereotyping, a simple form of the sort of process commonly classed under "clay" processes was illustrated. A plate of copper was roughened by glass-paper, rubbed over with white of egg, and then flooded with a white-wash composed as follows:—Stereotype-paste, as below, 6 oz.; whiting, 24 oz.; water, 3 pints. The stereotype-paste is made as follows:—Whiting, 6 lbs.; water, 2 galls.; flour (wheat), 4½ lbs.; boil, and add soft size, 14 lbs.; carbolic acid, 4 oz. Enough should be allowed to remain on the plate to form a layer 1-20th to 1-30th of an inch thick, and the plate is then set in a horizontal position to dry. A design can be readily traced with a point through the friable ground, and after the mould has been dried at about 200° Centigrade, a cast is made in the casting-box ordinarily used for the paper process. Apart from the operation of deepening the whites of the block and the making of the sketch, the whole work can be performed in ten minutes or so. The mixture used for coating the plate may serve to "raise" the whites on the mould, this preparation being put on by means of a pipette, but such a course was not recommended, as it involves delay in drying, and there is increased chance of the coating leaving the copper. The most essential point is the use of albumen on the roughened plate, this enabling a friable mixture to hold on sufficiently for practical purposes.

A cordial vote of thanks to the lecturer was passed, on the motion of the CHAIRMAN.

The lectures were illustrated by a large number of articles kindly lent by the makers, as follows:—Messrs. Richardson, Koolman and Isger, extensive series illustrating various stereotype methods for flat and round plates. Messss. Harrild and Sons, small stereotyping foundry, a set of tools, also their adjustable cores for casting type-high plates. Messrs. J. M. Powell and Son, portable casting-box, melting-pot, and tools, also mounting-blocks with catches capable of being drawn out singly. Mr. P. Barry and Mr. L. Nettleton, specimens of fine typographic casting in brass. Patent Printing Surface Company, specimens illustrating the making and using of rubber stereotypes. The Linotype Syndicate, matrices and casts illustrating their method. Mr. F. Plummer, set of specimens illustrating flat and curved stereotype work. Messrs. James Dellagana, formes, mould, and casts, finished and unfinished. Mr. D. C. Dallas and Messrs. Sharrow and Anderson, specimen showing the fineness of detail obtainable by the paper-mould method, also specimens by Messrs. Sharrow and Anderson illustrating the plaster process, as used by them for casting from music type. Mr. Harvey Dalziel, iron mounting blocks for stereotype plates. There were also exhibited some printing types cast from matrices made by photographic means; a fount of Arabic cast by the Typographic Etching Company for Messrs. Stephen Austin and Sons, of Hertford, being specially noticable. The lecturer also cast some type from matrices which he had himself made.

The lectures will be published in the *Journal* during the summer recess.

Proceedings of the Society.

INDIAN SECTION.

Thursday, February 27, 1890; Sir CHARLES BERNARD, K.C.S.I., in the chair.

The paper read was—

THE NORTHERN SHAN STATES OF BURMA AND THE BURMA - CHINA RAILWAY.

By W. WILLIAM SHERRIFF.

The kingdom of Upper Burma was annexed, by the proclamation of the 1st January, 1886, to the Indian dominions of her Most Gracious Majesty. Subsequently, about two years afterwards, active measures were adopted for bringing the many feudatory States of the eastern, western, and northern borders of that kingdom—States that had been under tribute to the kings of Burma—into subjection of the new government of the country.

The names of these tribes, it is interesting to note, are commonly short, and terminate with a nasal sound, such as Shans, Chins, Kachins, Paloungs, Tashôns, Karens, &c.

Next to the Burmese, in point of population, is that of the Shans, who inhabit the length of mountainous country that lies to the east and is parallel with the Burmese delta, between the 97th and 103rd degrees of eastern longitude. The Shans who occupy the country above 20° latitude belong to Burma, and those of them who dwell in the country below that line belong to Siam.

The extent of the Shan States now settled under British rule is about 80,000 square miles, or nearly as large as Great Britain, situated on this side of the Salween.

There are, besides these large tracts of country, the Trans-Salween States, which extend eastward across the Mekong (or Cambodia) river to the very confines of Tonquin, and that are peopled principally by the wild tribes of Las and Was, who, at the time of my visit to the country, recognised no form of government.

There were formerly as many as a hundred States, of varying size and importance, which were under tribute to the kings of Burma; but the generality of them rebelled against King Theebaw, and previous to the downfall of that monarch, in 1885, had asserted their independence.

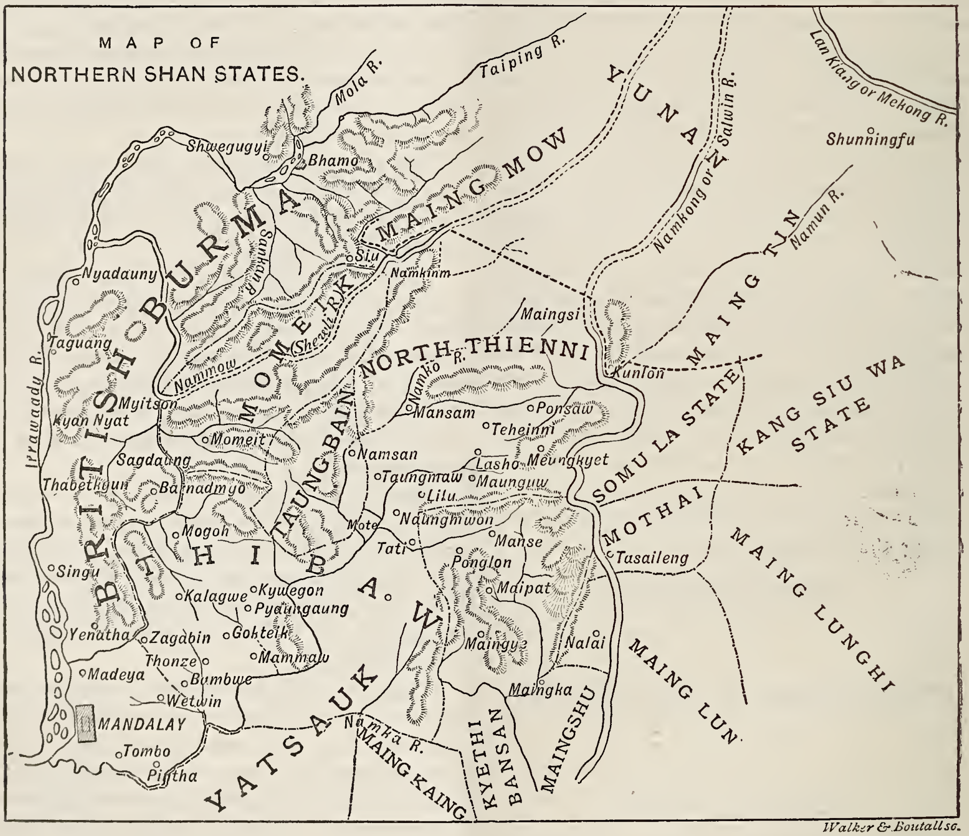
Their struggles for freedom, however, were followed by struggles amongst themselves, and in November, 1887, when two columns of our troops were sent (one to the north and the other to the south), the results of internecine strife—poverty, distress, and in some cases famine—were fearful to contemplate. The object to be gained by the expeditions just mentioned was accomplished speedily, without, it is said, the firing of a single shot; and forty-five larger and eighteen smaller States were subjugated, their rightful rulers discovered and placed in power, and tribute to the amount of Rs. 16,69,600 (£166,960 at par), payable, on fixed instalments, over a period of five years from 1888 to 1892 inclusive, was assessed. One notable exception in the levying of this tax was made in the case of Theebaw, one large northern State, on account of the

Sawbwa, who maintained after the taking of Mandalay, though often pressed by the neighbouring rulers to rebel, a friendly attitude towards ourselves.

Sawbwa, you will permit me to explain, is the Burmese name that is given to the Shan chiefs, or rulers; and Theebaw is the State from which the last Burmese king took his regal title.

Some other States were brought, during the course of last year, under our protection, and we may look for an early settlement of the Trans-Salween States on the north-east, which formerly owed allegiance to Burma.

Altogether, the political conditions of the country are of a satisfactory character; the liberty of the people is assured to them; the Sawbwas no longer hold the power of life and death; fighting between the States is forbidden, the disputes that arise have to be referred by the Sawbwas to the British Political Officers, of whom two reside in the States. Lieutenant Hugh Daly is Superintendent of the Northern States, with head-quarters at Lasheo; and Mr. J. G. Scott at Fort Stedman, or Monai, is Superintendent of the numerous Southern States.



Walker & Boutall sc.

To-day, I have the honour to speak to you about the Shan States of the north. Of the exact locality of these States I cannot do better, perhaps, than to observe that they are contiguous on the east to the famous ruby mines district, which is on the hills, about 80 miles direct north beyond Mandalay; and reached from Thabeitkyin (a river port on the left bank of the Irrawaddy) from whence also there is a road to Mogôk, the chief place in the mining district.

The three principal States of the north are Theebaw, Theinni, and Taungbaing. Theebaw and Theinni have attached to them several dependencies. Theinni, again, has been divided between two rival claimants for the Sawbwaship, into north and south.

The country itself is characterised by long, broad, open, fertile uplands at altitudes of 1,500 to 3,000 feet, and these are enclosed by mountains of the height of 4,500 to 9,000 feet above the sea-level. Down the sides of these mountains come torrents that feed the numerous streams in the valleys, which, in turn, flow into one or other of the great rivers of the peninsula, namely, the Irrawaddy, the Salween, and the Mêkong (Cambodia river).

The climate, during the dry season, from October to April, is cool and bracing; but in the other part of the year, the rainy season, it is raw and disagreeable.

As far as ways of transit are concerned, the country is not without its difficulties. The rivers are shallow, and flow through rocky defiles and, excepting in canoes or "dugouts," over short courses in the level valleys are not navigable. The only medium of communication is over animal tracks that have been made across the mountains. And for centuries commerce has been done in such goods only as could be carried along these ways on the backs of men and animals.

Last year, however, a few of the main paths were roughly levelled, and made wide enough to admit the two-wheeled country cart of Burma, which is drawn by a pair of bullocks. The Sawbwas are being encouraged to do this work. During the present dry season, improvements on an extensive scale are to be executed by them; and, doubtless, the effect of these improvements on the mercantile and moral condition of the people will be of a very favourable character.

When I was there I learnt that a wheeled vehicle, such as is in common use in the plains, had never been seen in Shanland.

The caravan traffic, so long interrupted by war, did not begin to revive until the close of the year 1887; but, from that time to the end of 1888, the small tax levied at Mandalay of two annas (2d.) per loaded coolie, and four annas (4d.) for each burdened animal, had been collected from 3,164 coolies, and 23,922 beasts of burden, arriving from all the Shan States.

There was, last year, a conspicuous increase in the number of caravans that came from the hill countries, and some went down further south to Toungoo and Maulmein, but at Mandalay itself there arrived, between the 1st of January and 30th of June—the first half of the year—as many as 2,284 coolies, and 16,408 animals, all of which were burdened.

The Shans are a sturdy, industrious race, and dwell chiefly on the plateaux. They are of medium stature, about five feet high, broad shouldered, and active. Their features may be described as coarse but not unpleasant; complexion, brown; nose, flat and wide; lips, thick and protruding; teeth, bad and made almost black by their constantly chewing betel-nut and tobacco; the ears of the male slit through the lobe (the longer the more fashionable the slit) to admit of a roll of paper of one or two inches in diameter. Males also cultivate a thin moustache but no beard, and tattoo the body, back and front, from neck to ankle, in indigo and red colours, in indescribably hideous patterns.

As to dress, the fashion is taken by both male and female from that which prevails in Burma. The exception to this rule is with the males, who do not don the Burman "paso," or kilt, but, instead of it, wear pants of very roomy dimensions. They wear also a large straw hat, the brim of which is seldom less than 100 inches in circumference, and which crowns the usual head-cloth that is entwined with the coils and top-knot of hair. These straw hats are of Chinese manufacture, and are brought in large quantities by the caravans from Yunnan. Some of them are of a very costly description, but the prices vary very much with the whiteness and fineness of the straw, and the number of plaits that are in the brim. A similar large sun-hat is worn by the women, in which there is a pointed crown, but they are made of common material, usually of bamboo leaves.

But the Shans, though they are the principal and the most numerous of the inhabitants of the hill country, are not the only people of those parts. There are on the summits and sides of the mountains a large and most interesting race of people called the Paloungs, who occupy the whole of the State of Taung'-baing; there are the Lishaws of the ruby mines district; there are the Kachins of divers tribes of the north; and there are the Panthay refugees from Yunnan who, after the suppression of the rebellion there, settled in large numbers near the Salween River. Besides, there are the wild tribes, who are found in the far east tract across the Salween River, and who are known as the Las and Was, and far away to the south, on the hills, direct east from Toungoo, are those pastoral and progressive tribes, the Karens, who have a special claim on English people since, as Asiatics, they are comparatively the most numerous and the most satisfactory converts to Christianity.

And to these may be added the Dunoos, a mixed race, the offspring of Burmese who had intermarried with Shans, and who dwell in small communities at the head of the passes that lead to Burma

Here I would notice the striking difference that there is between the ordinary Shans and the Upper Shans, or natives of the Chinese border States, particularly the difference that is so observable in Namkhan, a very rich border State on the north-west, subject to Theinni; and its ruler rendered allegiance while we were in his country last year. The Namkhanese are better looking, more refined, better dressed than their neighbours, and the costume of their women is the neatest of any that we saw.

To describe the manners, customs, and dress of the hill tribes of Burma would be to exceed the limit of this paper; but, with your permission, I would in brief terms like to refer to the very curious dress of the Paloung women of Taungbaing.

Unlike the majority of the women of Oriental countries, they are fond of dark colours, especially indigo. They wear a pointed cloth cap (night-cap shape); a short and close-fitting smock-jacket, which is put on over the head, the material of which is commonly black cotton velveteen and shaped like the letter V at the neck, both back and front, the hems being fringed with beads or braid; a short petticoat, also worn close to the body, terminating at the knees, and from the knees to the ankles is a narrow strip of cloth (similar in colour to the petticoat, oftenest indigo) swathed tightly as leggings, and showing a pretty red border at the last fold over the ankles. The personal adornment of these women are a thick brass or silver ring round the neck; one or more wrist bangles of the same metal; numerous coils of brass or copper wire, or of thin, blackened cane, hung at the ends with tassels of elaborate workmanship, worn very loosely round the waist; and last, but not least extraordinary of the ornaments worn by them is a silver tube of a foot in length, or larger than a piccolo, and quite an inch in diameter, thrust through the gashed lobe of the ear. Then to complete this already ponderous ornament, several strands of variegated worsted braid are passed through each tube, so as to hang gracefully at the ends. The Paloung damsels wear their hair fringed over the forehead, and do not don the cap alluded to until after marriage.

The dress of the Kachin women is similar to the one that we have described, but it is made of much coarser material, and decked with fewer ornaments.

Each tribe has its own peculiar language. The Shan commonly spoken is a tonal language, musical, high-pitched, and contrasting in a marked degree with the chopped and nasal sounds of the Burmese, notwithstanding that the same cypher-like characters—to the untutored eye they appear to be an arrangement of our figures 3, 6, 9, and 0, inverted and mixed in every way—are used by both people. The Shan language has an appalling number of vowel tones, and an incorrect modulation of the voice, however slight it may be, alters considerably the meaning of a word. A fluent speaker of Shan should be a good singer.

The standard of education among the Shans is not so high as in Burma, where a plain education for males may be obtained free in all the Buddhist monastery schools.

In the Shan States adjacent to Burma, Buddhism is the professed religion, but one is led to believe, from the lukewarm manner in which it is exhibited, that it was formerly forced upon the people by their Burmese masters.

The Paloungs of Taungbaing are strict and (judging from the great monasteries, pagodas, and other "works of merit" that we saw) very enthusiastic followers of Buddha. The other mountaineers, especially the Kachins, are spirit worshippers, and are grossly superstitious.

In manners and in morals the Kachins, who brew a strong kind of beer, and who are much addicted to drunkenness, are perhaps the most debased. The prominent vice of the Shans is that of gambling; it forms the chief pastime of the men, and at every fair or market there are special gambling booths erected.

The women and the children smoke a mild cheroot of herbs enclosed in a green leaf, and about an inch thick; but the men have a taste for tobacco, and carry amongst their belongings, ordinarily in the waist-belt, a pipe with a long stem and a capacious bowl. Considering that every man one meets is armed with a long sheathed knife or sword, a smaller dirk, and oftentimes a musket, the wonder is that violent crime is so very infrequent.

The Sawbwas live in large buildings that are built mostly of wood, fenced round by a stockade, and that resemble the Royal Palace at Mandalay. Their person is surrounded generally by a body-guard of two or three hundred musketeers, and sometimes a larger number even than that, when they tour through their districts.

Polygamy is practised by the official class, but not by the common people. Marriage is a civil contract, and it may, with the consent of both parties, be cancelled. The conditions of divorce, however, are somewhat stringent, and probably more than counter-balance the looseness of the marriage tie.

The dead are buried in about two feet of earth, and the grave is dug, when possible, on the property of the deceased, and enclosed with a bamboo fence.

Agriculture is the main occupation of the people. Almost the whole level of the plains, with the slopes of the hills laid in terrace-form, convenient for irrigation from the hill streams, are tilled with a care that one rarely sees in Burma. The largest product is rice, and owing to the abundance of water three crops annually are obtained in the central producing districts. Taungbaing is devoted wholly to the cultivation of tea; its mountain sides, which have very steep ascents and descents, and scarcely no open valleys, are covered with tea plantations. Evidently it pays the people to import the rice they consume from neighbouring States, and for which they pay four times more than the original price. Namsau, the capital of the tea country, occupies a very commanding site; it is in the midst of a panorama of mountain tops that are 5,000 to 8,000 feet above the level of the sea.

In the other States, tobacco, potatoes, wheat, cotton, and opium crops are raised, and the climate is suitable for the cultivation of almost every kind of European fruits and vegetables.

Cotton spinning and weaving and dyeing are the industries of the women and children when out-door labour is suspended. They work with simple tools, and their looms are of the most primitive kind, yet they turn out some excellent fabrics as regards both texture and design.

The manufacture of earthenware, bricks, and paper, is carried on for the purpose only of supplying the wants of the neighbourhood.

Pony breeding in some of the districts of Theinni is a source of considerable income; the Shan pony is noted for its activity, strength, and powers of endurance, and thousands of them are sent annually to Burma, Siam, and China. Pack-bullocks, too, in large numbers, are bred by the Shans; and the Panthays bring down, every year, strong and well-trained mules for sale.

THE BURMA-CHINA RAILWAY.

For considerably more than half a century the need of a road to China on the west, has been felt by the mercantile community of this country, and many of the ablest of our Indian administrators have evinced their feeling in favour of it.

Various routes, it is true, have been advocated, but the one that commends itself to our consideration is the line already opened from Rangoon to Mandalay, to be extended through Upper Burma. Any attempt, however, to explore and survey during the past twelve years (the period in which the subject has been earnestly discussed) was impossible on account of the disturbed political condition of Upper Burma. But now there are no such obstacles before us.

The rich and beautiful country in which there was no place allowed for European enterprise is, at the present moment, under British rule, and recent explorers to the frontiers have experienced little difficulty in discovering and determining the hitherto closed up trade ways.

It was natural enough for projectors of a road through Upper Burma to South-West China to fix upon what has been called the "Bhamo route," because a considerable stream of European trade has flown for many previous years towards that northern centre of the Irrawaddy river.

But much of that trade was forced through Bhamo owing to the dangers of travelling on the most ancient of all trade roads in and near to Burma—a road from Mandalay towards the north-east, laid through the heart of the North Shan States, particularly the principal and the largest of them, Theinni.

About forty years ago, when there appears to have existed a peaceful state of things and a flourishing trade, the Sawbwa of this powerful and wealthy State was confronted with a rebellion that he could not quell. He himself was deposed and sent into exile. (He was living, and still in exile, when I visited the country.) This rebellion the Burmese rulers who were sent up from Mandalay were unable to suppress. On the death of the leader there arose another rebellion, that was led by another chief, and that assumed yet greater strength, and against it also their arms were powerless. The effect of these insurrections on the trade of the country was of a most destructive character.

The Theinni road, rendered unsafe by lawless bands, was exentually closed, and the Chinese caravans that travelled along it were compelled to find a way over the numerous high mountain ranges that encompass Bhamo, and in this manner the place, as a "China route," came into prominence.

There is ground for believing that the

Theinni road would not only have been kept in a passable condition, but that it would have been opened again for traffic, had the King of Burma permitted Colonel (now General) Horace Browne's expedition of 1874 to proceed as proposed at the first, *viâ* Theinni.

It is now admitted generally by those who have special knowledge of the country, that the physical difficulties to be overcome are too great to afford the prospect of a railroad from Bhamo to China being executed immediately. Such, it is felt, would be the case were even the difficulties of the first stage of the line, between Mandalay and Bhamo, overcome.

Much that has been said in condemnation of the Bhamo route (as though it were the one only route through Upper Burma to China) would have helped but little to favour other proposed routes, had information been obtainable of the natural and perfectly easy road that runs through the centre of the Northern Cis-Salween plateau.

For political purposes Bhamo may, at least for some time to come, be important as a garrison town; and a line of railway, connected with that at present being constructed up the Moo River valley, might be run to a point opposite to it, but Bhamo itself, as a centre of commerce, is not likely to become of any great importance. A greater trade may be done between Bhamo and the surrounding mountain tribes on the north and north-east, and with the fertile State of Namkhan.

This country (I may say in passing) was opened, and roads over it were constructed by the forces of General G. B. Wolseley, that were sent, at the beginning of last year, to punish the marauding tribes that occupy the high fastnesses above Bhamo, and that have been for many generations the terror of traders, and of those who dwell in peace at the base of the mountains.

As I travelled from the Shan States to Bhamo, I was obliged to go through the midst of the country where these operations took place; and I saw for myself the fruits of peace that had been won by the courage and dash of the troops under General Wolseley's command. So much, then, for Bhamo and the trade of Bhamo.

The year 1889 is a year in the early history of the British administration in Upper Burma that is signalised by the opening of one of the greatest of the public works, the Mandalay Railway. Now, the proposal is to carry that railroad across the Shan plateau to the Yunnan frontier, by the oldest and most direct route that is known. And the reports of recent explorations are to the effect that there are no serious obstacles—none but those which are found in any hill country—none that the ordinary skill of our modern engineers cannot surmount.

The first point to be considered is that of ascent, and here I may observe that survey parties are now engaged, and that shortly we may hope to learn the results of their observations.

The present direct route from Mandalay is through the Kwetnappah Pass to Pyinulwin, which is the first plateau (3,600 feet), and thence, by a gradual decline, through Thônzè and Pyaungyaung to Thibawmyo (1,450 feet), the capital of the State of that name.

An alternative ascent from Mandalay by way of the valley of the Myitngè River has been suggested, and in favour of this ascent it has been urged that on the one hand it provides a longer and more gradual acclivity; and that, on the other, it avoids a gorge of considerable depth at Gôkteik. Of the gorge, however, nothing more need be said, for very recently a cart-road, that passes at a little to the west of the old road through the gorge, has been constructed.

But, apart from the consideration of cost in construction of the line, the first of the two routes will certainly be the best, inasmuch as it touches *en route* more important places. From Thibawmyo you would go up a gentle rising ground, and through the long aud open valley of Lasheo to Theinni (2,100 feet).

The last section makes for Kunlôn, a place on the Salween River, where there is a large ancient ferry, and it passes over fairly level ground, somewhat swampy, perhaps, at the present time, owing to past neglect of cultivation, a defect that will soon be remedied by revived industry and more peaceful times. Kunlôn, which in prosperous times was a place of much importance, marks the border of Theinni and Yunnan, and lies between the 23rd and 24th degrees of latitude. The whole distance from Mandalay to Kunlôn is 265 miles, of that number 50 only are in Upper Burma, the remainder being in independent Shan territory. The country north of Kunlôn is described as open, and, as far as Yunnanfu, the capital, quite easy of ascent.

The proposal to make the railway ascend from a point farther south, near Yémethen, has certainly the merit of taking in a large portion of the Southern Shan States; but these again could easily be reached by a branch line running south from Lasheo over perfectly level ground. The rulers generally expressed their willingness to make grants of lands, and to help forward, as far as possible, the construction of railways. And with an increase of wealth it is anticipated that branch lines will be projected and constructed at their own expense in every direction.

The Shans are celebrated for their trading instincts, and none of the people of Burma have welcomed the advent of the British so warmly as they. Very bright also are our prospects of trade amongst them. The crops that they cultivate, especially that of rice, are more abundant than they need for themselves, and consequently will shortly yield a large margin for export. They are very desirous of obtaining English fabrics, but these can be purchased only at prohibitive rates owing to difficulty of carriage. For the same reason the commonest wares of Birmingham and Sheffield, and all descriptions of hard goods, are prized as rarities. Small presents of tools, cutlery, &c., were eagerly sought by them on the occasion of my visit.

Nor should we forget that, to a great extent, the future quietness and prosperity of these countries are dependent on the facilities which we possess for successfully guarding the frontiers. And by a railway we can insure, in an eminent degree, a quick and cheap conveyance of troops, stores, and ordnance.

But further on this line of thought I need not go, since the value of the railway system in a country like the one under review is confessedly great. We return, then, to the point from which we digressed.

Besides the fertility of the land, there are rich stores of ore, of silver and precious stones, and these are known to exist in quantities large enough to yield a handsome revenue to the chiefs from mere surface workings.

The tea caravans from Taungbaing will certainly contribute largely to the profit of the railway. This is the principal feature of the carrying trade both to China and Burma, and the exports of the wet (or pickled) tea exceed those of the ordinary dry tea. As no records have been kept, it is difficult to form an estimate of the extent of this trade, but the natives themselves say about 30,000 bullock loads yearly, which would come close on 2,000 tons.

A special advantage to Burma would be that contractors and the officers of the Public Works Department would be able to obtain large and regular supplies of stone for State buildings, bridges, canals, irrigation works, river embankments, docks, and for road metalling.

In some of the districts in Upper Burma the new roads, cut at great expense, have almost become useless for want of stone metalling. It is not, however, for the sole purpose of developing the trade of the district that we advocate the construction of a railway through the Northern Shan States. There is the greater prospect for this country—the possibility of doing a vastly increased trade with China.

Goods of British manufacture, principally Yorkshire fabrics, distinctly Chinese in character, so much so that not a single yard of the stuff would sell among the Burmese, goods which I have seen in more or less quantities for the past twenty years, have been shipped from England, alike to the Eastern China ports of Shanghai, &c., and to Rangoon for Yunnan. These goods have found their destination on the backs of animals travelling over the Shan hills, and the sale of them could at once be increased a hundred-fold by cheaper and quicker transit by railway, and the same increase would follow in the case of a thousand other kinds of goods which are saleable in China.

Attention has, of late, been drawn to the smallness of our trade with China, scarcely a fourth of what it is with India. Let us take one great staple article like cotton piece-goods, of which, last year, India and Burma took slightly over 2,000 millions of yards; while China ports (including Hong Kong) took only 474,426,100 yards, or less than a fourth. The total value of all British trade with China was £6,500,000 sterling for each of the years 1887 and 1888, whilst for India and Burma it stood at £32,000,000 and £33,000,000 respectively.

Considering the greater population and the trading proclivities of the Chinese, this is not as it should be. As I have already remarked in another place, our trade having fringed only the east coast, has yet to reach the great inland provinces of the Celestial Empire.

Slowly, but surely, the feeling in favour of railways is extending in China; when once we have reached their border, there is every reason to believe that the Chinese themselves will undertake an extension of the line to the capital of Yunnan; or, which is the same thing, commission an European syndicate to do it for them.

I met a large trader from Momein in Yunnan, returning through the Northern Shan States, who informed me that there was a strong feeling in favour of railroads, and that we might expect our line when laid to enter their own country. But whether that would happen or not, he was sure that all the Chinese traders would readily avail themselves of the advantages that the railroad offered. He further mentioned having journeyed many years between Momein and Mandalay, a distance of about 330 miles, that the most direct road was the Theinni road, and that the news of the pacification of the Shan States would quickly spread in Yunnan and the surrounding countries, and would bring down a large increase of traders during the dry season. Whilst the road was blocked by Shans fighting, he had tried to run his caravans through the Siamese States down to Maulmein, in Lower Burma, but only once succeeded in reaching the latter place, and then only under such great risks and difficulties which would not pay him to attempt the journey again. I learnt also from this interesting traveller that most of the Yunnanese merchants have agents at Mandalay, if they have not actually at that place a branch establishment.

With regard to the cost of the proposed railway, I am of opinion that it ought not to exceed that of the Mandalay line, which was estimated at three-fourths of a lakh per mile, and that it ought to be constructed in about the same period, or perhaps, three years altogether. Labour, abundant and cheap, can be got in the Shan States, and the Sawbwas through whose territory the line will run, and with whom I frequently discussed the matter, will aid the work of construction by every means in their power.

Before I close this paper, I will (with your permission) make brief reference to the proposed line from Burma to China by way of Siam.

Surveys of the country were made about six years ago, with a view to forming a road between South-Western China, by way of Maulmein, through Siam; and I am bound to say that any vital interest in the question which one may find is mainly due to the persistent efforts of the promoters of this line to spread information. And it is confessedly a scheme that does honour to those who propounded it, because, as I understand the scheme, it aims ultimately at girdling Central Asia with a network of railways, beginning at the Persian Gulf, connecting the Indian railways through Assam to the lines proposed for Burma and Siam and China, and then extending to the farthest shore of the China sea—a work, if it should become an accomplished fact, that will effectuate changes of a marvellous character. The Siam railway, *via* Raheng and Ssumao is strenuously presented to the public as the only one that is deserving of attention.

In the November number of *Blackwood* the projector of the Siam railway writes thus:—"The more the subject is examined, the more evident does it become that the only possible railway connection between Burma and China must be by the Maulmein route projected by us. It is a case of that or nothing."

It is difficult to conceive of a form of expression stronger than the one we have quoted. And yet, let it be remembered, it is traced in the light of information received nearly six years ago.

The only parallel to advocacy like this is to be found in one who, in the light of Stanley's recent discoveries, would venture a similar rash assertion favouring schemes of communication in Equatorial Africa, put forth on the strength of the superseded explorations that were made some years ago.

I maintain that the acquisition of Upper Burma has altered entirely the aspect of Indo-China exploration. Countries of which we knew a short time ago absolutely nothing—which were jealously guarded against European enterprise—are now open to the explorer and trader.

Besides, this Siam scheme affects Burma to the extent only of sixty or seventy miles across the Tennasserim littoral, and is confined almost entirely to Siam, the survey having been made chiefly in that country, and in no higher latitude than about 21°. Much of the work proposed could no doubt be done if the capital needed be realised, and to the community at large it would be an unspeakable advantage; but to state, in pleading for it, that it is the only way of reaching China is wholly misleading, and not according to fact. The great cost of the line (it is proposed to put down nearly a thousand miles of rail); the fact that nearly the whole of it passes through foreign territory; the further probability that it would, sooner or later, lead to a clashing of interests with the kingdom of Siam, with which we are now on friendly terms; these are reasons that could be employed at the present time against the practicability of the scheme.

But, on the other hand, it is to be argued, in favour of extending the present line of railway from Upper Burma, that there are only 300 miles, perhaps less, to plant, and we reach the borders of land-locked China.

Moreover, by executing this work, we

develop countries that are under our control; that are peopled by a most progressive race; and that contain all manner of natural riches; and, by doing it, we bring ourselves within a measurable distance of a happy consummation of the hopes of the last half century.

The accuracy then of the statement that there is no other way possible but through Siam of connecting Burma and China, I challenge. Any one of us might, with just as much reason, say that a railway already opened from Cardiff to Preston could not be continued to the Scottish border, or, say, to Glasgow; that further than Preston it was impossible to take it, and that if ever you reach the far North by rail you must make a fresh beginning at Bristol, pass through the Midlands, the East Riding of Yorkshire, and the mining districts of Durham and Northumberland.

I have now, to the best of my ability, tried to explain to you, and through your honourable Society to impress upon the commercial community of this country, the importance of opening at once the door of the western continent of China, to show that if there were even half a dozen difficult ascents to be surmounted before the plateau was reached, and as many chasms to be bridged, it was still the work appointed us, and that if the Government of India cannot undertake it, it should be done by private enterprise. More I cannot say, unless it be to the effect that it is a work that will produce results as beneficial and as great as those that were associated with the opening of the overland route, and the railways across the great peninsula of India.

DISCUSSION.

The Rev. C. W. MITCHIL said he had listened to this paper with much interest, and he was looking forward to the time when such a railway as had been described would be made. Having lived twelve years in China, he knew something about the commerce between that country and this, though he had been engaged in mission work. Both Yunnan and Szchuen were very important provinces, with which an extensive trade might be done if facilities were afforded.

Mr. OGILVIE HAY said this subject had occupied his attention for many years, and he was very glad to hear that there was at length a prospect of reaching China through Burma. He had reason to believe, from other sources of information, that the surveys now being carried on were very favourable, and he hoped that in three or four years there would be a railway station on the confines of China.

Mr. HOLT HALLETT said Mr. Sherriff's description of the Shan States to the west of the Salween, in which the valleys in the uplands were depicted at altitudes of 1,500 feet to 3,000 feet, separated from each other by mountains from 4,500 feet to 9,000 feet in elevation above the sea, and with the stream beds in the valley bottoms rushing through rocky defiles, together with his journey across the Taungbaing State to Namkhan, on the Shweli river, in which he crossed a spur at an elevation of 7,000 feet, should have given him some idea of the difficulties which were likely to be encountered between the Kunlon ferry and Yunnan-fu, the capital of Yunnan, and make him exceedingly cautious in accepting the native information about the physical aspect of the country from the ferry to the capital, across which he projected, solely upon native information, to carry a railway. The utter worthlessness of this class of information could be judged by comparing the statement of Dr. Clement Williams, formerly agent to the Government of India at Mandalay, in his book "Through Burmah to Western China," which was published in 1868, before the Bhamo route had been surveyed by Mr. Colborne Baber, with the survey and description of the route given by that accomplished traveller and able official. Dr. Williams noted that he had "been informed by travellers who had been there, that from Moungsun (a Shan town in the valley of the Shweli, near Namkhan) there is an almost uninterrupted plain across to the city of Yunnan, and that this direct route to that important capital passes over no mountain passes whatever." This information is curiously similar to, indeed exactly the same as, that solely relied upon by Mr. Sherriff in aligning his projected route from the Kunlon ferry to Yunnan-fu. Now, to cross this so-thought uninterrupted plain with a railway, Mr. Colborne Baber estimated that half a dozen Mont Cenis tunnels and a few Menai bridges would be necessary. Even Mr. Sherriff allowed that, "it is now admitted generally by those who have special knowledge of the country, that the physical difficulties to be overcome are too great to afford the prospect of a railway from Bhamo to China (Yunnan-fu) being executed immediately." No European explorer had crossed the country eastward from the Kunlon ferry towards Yunnan-fu, but to the south of the Kunlon ferry the Salween was crossed some years ago by Dr. Cushing at the Takaw ferry. This missionary reported that between the ferry and Kiang Tung he ascended and descended no less than eight mountains, and that one of the passes was at an elevation of 6,500 feet. In 1837, Macleod crossed five ranges of hills between Kiang Tung and Kiang Hung before reaching the Mekong, or Cambodia river. We thus know that the Bhamo route, which proceeds eastwards, crossing the Salween about 130 miles to the north of the Kunlon ferry, is unfit for railway construction and that the Takaw ferry route which crosses the Salween about 130 miles to the north of the Kunlon ferry route passes over a mass of mountains across which it would be extremely expensive to carry a railway to the Mekong. What better prospect was there for carrying a railway eastwards from the Kunlon ferry to the Mekong? If, instead of taking his information solely from native caravan men, Mr. Sherriff had studied the account given by Mr. Colquhoun, Mr. Baber, Mr. Hosie, Mr. Bourne, and Mr. Garnier, all of whom had travelled in Yunnan, he would have found that there could be no easy ascent from the Kunlon ferry to Yunnan-fu. He would have known that the Mekong, to the north of Kiang Hung, run in a great defile, which would have to be descended and ascended by his projected line to the capital, that the hills bounding the Papien valley on both sides would have to be crossed, as well as the hills which separate the valley of the Yuen-kiang river from the watershed of the Yangtsze-kiang. Then the great mountains which separate the Salween river from the Mekong had likewise to be taken into consideration. The information which Mr. Sherriff had derived from the caravan men, that the country north of the Kunlon ferry is "open, and as far as Yunnan-fu, the capital, quite easy of ascent," was, therefore, utterly absurd, and totally unworthy of credence. Mr. Sherriff's description of the physical geography of the country in the Shan States to the west of the Salween was not as accurate as it would have been if he had had the training of an engineer. His detail of the altitudes of the country between Mandelay and Theebaw, taking Mandalay as 300 feet above the sea, implied that the total of the rises and falls between those places amounted to only 5,450 feet, whereas a reference to the Government surveys of this section of his route shows that the total ascents and descents in this short distance amount to no less than 12,000 feet. Again, his description of the country between Theinni and the Kunlon ferry as "fairly level ground" did not tally with that of officials who had traversed the route and have reported that 20 miles out of the 52 miles is very difficult, and that on this portion of the route the range of mountains which divide the waters of the Irrawaddi from those of the Salween has to be crossed. Turning to the criticisms which Mr. Sherriff had thought fit to make on the projected Burma-Siam China Railway, it was unfair and not correct to speak of the line as being 1,000 miles long, and as lying for only sixty or seventy miles in British territory. From our Burmese seaport, Maulmein, to our eastern frontier with Siam, the chairman (Sir Charles Bernard) estimated the length of a railway would be 80 miles. The total length of the next section from our frontier at Myawaddi, through Siamese territory, to our frontier with the Siamese Shan States at Kiang Hsen, on the Mekong, is estimated at 375 miles. The following, or third section, runs from Kiang Hsen, through the British Shan States lying in the valley of the Mekong, and past Kiang Hung to Ssumao, the frontier post of south-western China, aud this section is estimated at 245 miles. The three sections together give a total of 700 miles, of which 325 miles lie in British territory. When passing through Burma in 1885, the Chairman, who was then Chief Commissioner of that Province, informed him that he had received a letter from Mr. Satow, our minister at Bangkok, stating that he believed if the Government of India would consent to construct the section of the railway from Maulmein to the Siamese frontier, that the King of Siam would be willing to meet the British line with a railway from Bangkok, thus forming the base for the extension of the line to China. Sir Andrew Clark had since then arranged with the King of Siam for the survey of a main line from Bangkok right up to the British border at Kiang Hsen. If it consented to make the 80 miles from Maulmein to Myawaddi the Government of India could easily induce the Siamese to connect our terminus at Myawaddi, with their main line, and thus complete the British and Siamese portions of the projected railway as far as Kiang Hsen, from whence the line could be continued through British territory to Ssumao, on the Chinese frontier. To show how much better this work was, in an engineering sense than the one which was advocated by Mr. Sherriff, he would point out that Maulmein lay on the east bank of the Salween river, whereas between Mandalay and the Salween, a crow-line distance as great as from London to Liverpool, the country was filled up by a great precipitous-sided plateau, riven by great ravines, and crested by numerous high ranges of mountains. The whole of this difficult region would be avoided by following our projected line, which has its starting point at Maulmein, a seaport situated on the east bank of the Salween. Again, Ssumao, the point aimed at by the Burma-Siam-China Railway, lay as far as London does from Manchester to the east of the Kunlôn ferry, and is on the China side of the great barrier of hills which separated the Salween from the Mekong, and might well be called the great west wall of China. Now, although Mandalay lies in a crow-line only 170 miles from the Kunlon ferry, Mr. Sherriff allowed that the length of the mule route betwixt these two places is 265 miles, or half again as long as the crow-line distance. This of itself speaks of the difficult character of the country. A railway, however, could not follow the same course as a mule track, it would have to zig-zag over the mountains and up and down the ravines with much easier and, therefore, longer gradients. It would probably not be less than 400 miles between the two places. Mandalay lies 386 miles by rail from Rangoon; the distance from Rangoon to the Kunlon ferry, over the Salween, may therefore be taken as approximately 786 miles, or 86 miles further than Ssumao would be from Maulmein. A railway to the Kunlon ferry would undoubtedly be of great use in opening up the northern Shan States, lying to the west of the Salween river, and in increasing our trade with the Chinese Shan States which lay between the Kunlon ferry and the Chinese provinces of Yunnan, it would likewise develop our trade with the mountainous regions in the north-west of that province, and he therefore strongly advocated its construction; but to enable the British to reach a point in China, like Ssumao, from which the Chinese could construct a system of railways through their southern and central provinces, the Kunlon ferry route was useless. It was a fact beyond question that the shortest line from a British port with this object in view was that projected by himself and Mr. Colquhoun, and this was the only practicable line by which we could compete with the French for the trade of Southern and Central India. Another advantage of the Burma-Siam-China railway was that it opened up the Siamese dominions, which, according to the latest accounts contained at least 10,000,000 inhabitants, to British and British-Indian enterprise from Burma. It did not speak well for the enterprise of the Government of India that for sixty-five years we had been neighbours to Siam, and the Siamese Shan States, and had a seaport at Maulmein, within sixty miles of the Siamese frontier, yet had taken no steps to further trade with those regions. All projects for the connection of the countries had been cold-shouldered, and neither railway nor even a cart-road had been constructed to that frontier, and up to the present time the Government had shown no inclination to move in the matter. Such a state of things should not be allowed to continue, the Burma-Siam-China railway, which in no way conflicts with the projected Kunlon ferry route, as it opens up an entirely different country, including our Shan States in the valley of the Mekong, should speedily be constructed. Whatever other lines might be advocated and constructed by the Government, it was certain that the trade of China, as well as that of our Eastern Shan States and a large part of the Siamese dominions, would eventually pass *viâ* the Burma-Siam-China railway to Maulmein.

Mr. HYDE CLARKE remarked that the word "Shan" was not the name of a particular tribe, but was simply Chinese for a mountain, so that the Shans really meant mountain tribes.

Mr. MARTIN WOOD thought Mr. Holt Hallett had, from an engineering point of view, nearly demolished Mr. Sherriff's scheme as a plan for reaching South-Western China, but he had also disposed of a somewhat similar plan of his own and Mr. Colquhoun's. He believed the Chairman would agree with him that the idea of carrying a railway through those mountains to South-Western China could never be carried out commercially, not because the engineering difficulties would be insuperable, but because the cost would be so great. Mr. Hallett's own scheme was not before the meeting, but it was at any rate entitled to respect, as he had spent years upon it; and having abandoned a former plan, had now brought forward one which was more in accord with physical geography, at any rate, whatever it might be from the political point of view. He, however, objected to all these schemes. Mr. Sherriff had described the efficiency with which traffic was at present carried over the hills by means of mules and other animals, and indicated how it might be facilitated; and as we had only just got into Upper Burma, was it not better to wait a bit and see how that traffic could be extended? Peace and quiet had been secured, which would attract people into the country, and it was always a better policy to attract people into your own territory rather than thrust yourselves into other people's. But a more serious question was this; was not the proper route into south-western China by water—by sea and the Yangtsi? Of course the distance was considerably greater, but the cost of railway transport was always enormous compared to water carriage. Something had been said about the Chinese taking to railways, and one gentleman went so far as to foresee the time when they would carry a railway into Yunnan; but that time was probably far distant, and long before then they might be induced to allow steam navigation on the rivers. Some merchant might be able to give an approximate estimate of the difference in the cost of carriage, but he held it would be enormously in favour of water. Mr. Sherriff had kept in the background the important question which lay at the root of the whole—how was the capital to be obtained? He said if the Government of India could not do it, let private enterprise step in. By all means; but then he should have addressed his paper to the London Chamber of Commerce, or the Balloon Society, for as a commercial venture he thought it was very much up in the clouds. He had listened for what could be said about the gradients, but found nothing but general statements as to the height of the mountains, and Mr. Hallett appeared to have dealt with that point in a very emphatic manner. No reference was made, either, as to how fuel was to be provided for the railway. If they were to depend upon wood, that alone condemned the project, and though it was supposed that there were coal and petroleum beds, no definite information was available as to their proximity to the route. Many Englishmen had analmost fanatical idea about railways, based upon our own experience in this small island, with its stores of coal and iron in close proximity; but the conditions of traffic and commerce, and the distances to be traversed in other parts of the world, were totally different from our circumstances.

Mr. W. S. SETON-KARR was rather inclined to take the same line as the last speaker, and ask where the money was to come from. The cost was estimated at three-quarters of a lac, or £75,000, a mile, but he much doubted if the line could be completed for that sum in such a country. He was not at all competent to give an opinion as to which was the best route, and could only speak with diffidence. Three or four years ago he read an interesting work by a gentleman who had been in Siam, and when he got high up the river beyond Bangkok he found the difficulties of travelling, from the mountains and the population, very formidable, and he should like to see the King of Siam construct his railway first. Mr. Sherriff had said a great deal about the mines and development of the resources of the country, which reminded him of his experience in India. Whenever a province was to be annexed there had always a great talk about coal and iron, and other mineral wealth, which was to be found in abundance; but when the annexation had taken place, either it was found that the ore was thin, or the experts had been deceived, or the difficulties of working were very great, or it required steam power, or something or other; he had never seen realised the grand expectations about the development of the resources of the new country. The state of the roads was described as being very bad; but why did they not do as in Bengal, which hardly had a stone in the whole province? But there they managed to construct very good roads with burnt brick. In conclusion, he would say that the difference of opinion which had been expressed in no way lessened the admiration he felt for the energy and enterprise which both gentlemen had shown in their respective explorations.

Mr. H. SHERRIFF said the point had been mooted that it would be better for English people to construct a railway which ran for 300 miles through British territory than one of 1,000 miles through that of our neighbours, and there was great force in that. With regard to the scheme for a railway through Siam, he had lately heard Captain Loftus, an officer in the navy of the King of Siam, express the opinion that it was not at all likely the King would allow one to be constructed to Maulmein, but would divert it to Bangkok, if it were made at all, and it would not, therefore, form a connection with India. His brother had been through the neighbourhood he described, and Mr. Hallett had not, and he should therefore prefer the opinion of the former. He had read Mr. Hallett's work on Siam with great pleasure, and if a railway were made there it would be a great thing for England, but he felt sure there was traffic enough for both routes.

Mr. W. SHERRIFF said he was not able to reply so fully as he could have wished, as he was suffering from an attack of deafness, and had not heard a great deal of what had been said. He was very pleased to meet Mr. Hallett, whose work he had followed with great interest from the commencement. A great deal too much was said about Tonquin, and about France outdoing England in connection with China. In the first place, the French had to settle the country and govern it; and in the second place, if they succeeded in constructing a railway we should use it for them, as we had used the Suez Canal; but in that case our commerce would have to go hundreds of miles round to reach Tonquin, and would thus be greatly handicapped in comparison with the straighter route *viâ* Rangoon. He expected that in a short time the railway would be an accomplished fact, and then he should be happy to assist Mr. Hallett in getting his line made through Siam.

The CHAIRMAN, in proposing a vote of thanks to Mr. Sherriff, whose enterprise they all appreciated, said they were also much indebted to Mr. Hallett for putting forward his view of the question. The question of communication with Western China was interesting not only to commercial men in England and its great dependency, but also to all Indian officials. He heard only a few weeks ago from the Chief Commissioner of Burma that the survey was being carried out along the alternative routes which Mr. Sherriff had described; and until those surveyors returned it was premature to express a decided opinion as to which would be found the easiest and best. Mr. Hallett had given an account of the great mountains in Taungbaing on the Bhamo route, and on the line of the Takaw ferry route, and he was perfectly correct in saying that they would be very awkward places to carry a railroad over, but they did not happen to be on or near the route Mr. Sherriff had described. Therefore, while shuddering at those enormous heights, they need not, by reason of those lofty passes, be alarmed for the success of the railway. What the difficulties would really be they could not say until the survey was made. Mr Scott, the political officer in those parts, had been over the line; he spoke the Shan language, and his impression from the inquiries he had made was that the Kunlôn ferry route would turn out to be the best. Whichever way the great Yunnan plateau was approached, there was an ascent from something under 2,000 feet to something over 6,000 feet elevation to be made, and the question was, as Mr. Hallett had pointed out, how to reach that elevation without too many ups and downs on the way. He believed there was not a railway which could be made anywhere on the face of the globe which would not be an advantage to British commerce, and even if the China line were made from Bangkok to Western China, it would be principally British commerce which would use it; and so it would be with a line from Tonquin into the valley of the Canton river. Still, if British capital had to be used, and especially, if in any way, direct or indirect, the Indian treasury was to be answerable for the finance of the railway, there were very strong reasons for carrying the line as far as possible through British Indian territory. Mr. Martin Wood had spoken of river routes, and it was quite true that no railway taken into South-Western China could ever compete with river carriage so far as the country which lay below the great rock barrier of the Yangtsi was concerned. What might happen beyond he could not say. His own idea was, that however the great province of Szechuen, with a hundred million inhabitants, was to be got at, the portions of China which would be tapped by the railways spoken of would be south of Szechuen and Yunnan, and the western part of Kwangsi, which were served to a certain extent by the Canton river. Mr. Colquhoun went a long way up that river in a boat, and left it when he had to turn down southward in order to reach the Shan border. These two river routes they could not hope to compete with by railways, but there was an immense country which the rivers did not serve; and there railways might be useful. Those who took an interest in this matter should remember that one of the proposed routes lay entirely through and served entirely British territory, while the other did not, and if the Bangkok harbour were improved, the principal part of the China trade would find its way thither rather than to Rangoon or Maulmein. Apart from the railway question, the paper gave a very interesting account of the Shan people, a people whose talent for trade was hardly rivalled even by the Scotch. They would travel 500, 600, or 700 miles twice a year for trading purposes; they were a brave, hardy people, and they were the first if not the only people in Upper Burma to receive the English with a welcome. They were called, by the reader of the paper, independent Shans, but he should rather call them dependent, as the chiefs paid a tribute to the Queen. They had received patents under which they held their territory from the Queen, and in one of the first patents, under Lord Dufferin's orders, he was very glad to insert a clause whereby these chiefs bound themselves whenever a railway was made through their country to give the land necessary, and to aid its construction in every possible way. The reader of the paper spoke of the Theebaw country as the best managed and most forward of any of the Shan States, and the history of the chief was very remarkable. When the Shan country was subordinate to Burma, the chief fell out with the king at Mandalay, and had to flee to British Burma, where he found an asylum in a village about two miles from Rangoon. The Government of Upper Burma sent emissaries to see what he was doing, and as he thought, to kill him; and taking the initiative, he shot two of them. For this, being on British territory, he was arrested, tried, convicted, and sentenced to death, but the sentence was commuted, and after about a year's imprisonment he was released and allowed to go back, though he did not dare to reappear in his own province. When the Queen's troops got to Mandalay, however, he went back to his own province, was received with acclamation, re-established himself, and began to restore peace. Burmese, Chinese, and other emissaries tried to set him against the British, but in vain. Some of his answers were intercepted, and in them he said he knew the British, who had restored him his life when it was forfeited by their laws, and enabled him to regain his kingdom, and he should always be their friend. He was the first Shan chief who came down to Mandalay and submitted to the Queen of England, though his previous experience in her Majesty's territories had been as an inmate of a British jail.

THIRTEENTH ORDINARY MEETING.

Wednesday, March 5th, 1890; H. TRUEMAN WOOD, M.A., Secretary of the Society (in the absence, through illness, of the Astronomer-Royal), in the chair.

The following candidates were proposed for election as members of the Society:—

Dalby-Welch, Reginald, Broad-street-avenue, New Broad-street, E.C.
MacRitchie, James, Singapore, Straits Settlements.
Scales, George McArthur, Belvoir-house, Hornsey-lane, N.
Shelley, Joseph Ball, Southlands, Longton, Stoke-on-Trent, Staffordshire.

The following candidates were balloted for and duly elected members of the Society:—

Fellows, James I., Saxon-hall, Palace-court, Bayswater, W.
Gloag, Lieut.-General Archibald Robertson, 2, Mitre-court-buildings, Inner Temple, E.C.
Hart, Captain Herbert, Fairview, Stamford.
Jebb, George R., Birmingham Canal Navigations, Birmingham.
Radcliffe, Francis, 233, Burrage-road, Plumstead, Kent.
Tagg, Thomas George, Island Boat Building Works, East Molesey, Surrey.
Wing, William, 7, North Church-street, Sheffield.

The paper read was—

RECENT PROGRESS IN BRITISH WATCH AND CLOCKMAKING.

BY JULIEN TRIPPLIN.

At the request of the Council of the Society of Arts, I have this evening to read to you a paper on the progress made in England in watch and clockmaking during the last ten years. The Council was probably induced to confer this distinction upon me, knowing that part of my life has been passed in the manufacturing districts of Switzerland, France, and England, and also on account of my having had the honour to serve as the English juror at the late Paris Exhibition. The conclusions I drew from the examination of the many exhibits there may enable me to bring a few facts before you in connection with the development of English watch and clockmaking, as compared with that of Continental manufacturers.

The one fact which that great Exhibition has made patent, not only to me but to the eyes of all competitors, is that the English watch and clockmaking trade has awakened from a long lethargy and has entered on a veritable Renaissance. The time at my disposal, according to the rules of this Society—one hour—is short to properly treat so extensive a subject, as I shall have occasion to revert in the course of my remarks to our past condition.

At Paris, there were altogether 500 clock and watchmaking exhibits, coming from Austria, the Argentine Republic, Belgium, England, France with five centres (Besançon, Haute Savoie, Beaucourt District, St. Nicholas d'Alièremont, and Paris), Italy, Japan, Roumania, Switzerland (with its 147 exhibitors), and the United States of America. Of these 150 were watch and 37 clock manufacturers, and these are the only sections that need occupy me at present, as they will be the subject of my paper.

As most people are now well aware, considerable changes have recently taken place in the way of producing timekeeping mechanisms. A rough distinction is made between the old and new methods by the terms "hand-made" and "machine-made," and for the purposes of this paper I have adopted these terms, pointing out that when examined closely no line of demarcation can be found; these being purely a question of degree, the one method slides gradually into the other by insensible steps, and, after all, the material point for the consumer is not how a thing is made, but its price and quality.

Taking the class of watch manufacturers, the somewhat large number of 150 exhibitors may at once be separated into two groups, viz.:—

A.—Manufacturers by the new mechanical processes, that is to say, those who by means of steam or hydraulic power, new appliances, improved organisations, and larger output, make the whole or part of the watch on the interchangeable system.

B.—Those makers who follow the old mode of watchmaking, still almost exclusively in use in Clerkenwell, partly at Coventry, and also at Besançon and parts of Switzerland, wherein the rough movement is produced in places which are far distant from those localities in which the finishing operations of jewelling, dial-making, 'scaping, chasing, finishing, timing, and adjusting are done under a system of subletting to small makers who work at their own homes.

Of the former there were 25, and of the latter 125 exhibitors. Dividing these again into nationalities we found that in Group A (25) England had 1, France 6, Switzerland 16, America 2; while in Group B (125) England again had 1, France 49, and Switzerland 75. This classification is of course not sharply defined as in some cases it became difficult to discriminate, but it facilitates the task of examining and comparing.

The importance of the question of watchmaking by mechanical processes, suggesting as it does a large, complicated and complete manufacture, deserved from the members of the jury some analysis. A small amount of investigation made it clear that under this heading were grouped a number of manufacturers who differed widely in the extent to which they carried out the principle; indeed, five fairly-well defined divisions were seen to exist. These may be stated as follows:—

A.--The watchmakers using automatic appliances more or less in the making of plates and barrels, and of various parts of the watch, but who obtain wheels and pinions from outside their own organisations.

B.—Those firms making the movement complete, including wheels and pinions, but not the parts of the escapement.

C.—Those who couple the finishing process with the operations of Group B, but who yet obtain the parts of the escapement outside.

D.—Firms who add casemaking (sometimes only in metal and silver, sometimes both in silver and gold) to the operations of Group C; still, however, obtaining the parts of the escapement from elsewhere.

E.—Those firms whose organisation embraces the making and finishing of the whole of the parts of the watch and the case, except the specialised parts of the main-spring, balance-spring, hands, and perhaps jewel holes.

Accepting these divisions as in the main indicative of various degrees of watchmaking by machinery, although it is true they interlace in great complexity, and applying this analysis to last year's exhibition, it was noticed that Switzerland, so strong in collectivity, was comparatively weak in category of type E.

Looking at the testimony of the exhibits themselves, we found none that realised the conditions of Group E, except the English firm of Rotherham and Sons (and perhaps that of Messrs. Japy Frères, and the well-known Waterbury Company of America; but these two firms only deal with metal-cased watches of less than ten shillings in cost, and can scarcely be considered when speaking of watches of precision), and this firm thus at once attracted attention, even among so large a number of exhibitors taking part in the competition.

It is difficult to assign a reason why the Swiss have not yet carried their revision of operations far enough to cover the ground that the American and English companies consider the ultimate necessary extension of the modern mode of manufacture. Probably the causes are manifold; it may be large command of skilled labour and an extensive subdivision in their older method having created certain vested interests in the community and making it more difficult to change; or it may be the large capital required and the absence of joint stock enterprise in Switzerland. Again, the cheapness of their productions, made under their old methods, would naturally at first render them freer from competition, and so necessity, which on close investigation is always seen to be the compelling agent, was not early felt by them. Be this as it may, there can be little doubt to-day of the enormous gain of carrying the combinations to the extent of Group E; it is in fact the only rational course which meets the requirements of this present time.

Before entering into a more detailed consideration of this Group E, which forms the main body of my remarks, allow me to say a few words on the British Section as it was arranged in Paris last year. I have prepared an illustration which we will throw upon the screen to convey a clear idea of it to your minds.

This section had a compact and collective appearance, and as such arrested attention. The exhibitors were chronometer-makers, turret-clock makers, and watch manufacturers by both methods; a school of horology, tools and materials, and literature, were also represented. It differed widely from that of previous exhibitions in many ways. Formerly the few exhibitors were scattered about, and their stands arranged with small counters for purposes of sale, justifying in some measure the Continental sneer, "that England is a nation of shopkeepers." In the present instance the very reverse was the order of the day, the firms exhibiting were of weight and substance (chiefly *bona fide* manufacturers), and were for the most part induced to do so from patriotic motives, endeavouring to counteract by ocular demonstration the feeling which had begun to take root in the public mind, that English watch and clock making was a thing of the past.

The representative character of the exhibitors, and the substantial merits of their exhibits, greatly impressed the jury, and obtained for our Section the unprecedented number of awards it received, namely, 200 per cent., including the collaborateur's medals—in fact, in point of merit, the Watch and Clock Making Section stood before all others in the Exhibition.

In chronometry, Mr. V. Kullberg carried the palm from all competitors. Messrs. Dent, of the Strand, and Gillett and Johnston, worthily sustained our reputation for public clocks, this last firm emphatically so. Messrs. Grimshaw and Baxter's exhibit of watch and clock tools and materials was large, and representative of the excellence of our products in this particular; while Messrs. Usher and Cole, Parkinson and Frodsham, and Webster, of Queen Victoria-street, showed that the traditional skill of Clerkenwell was still the best of its kind. For the first time, too, an English school of horology presented itself to the consideration of a jury, and we must note, in this new departure, a happy augury for our future. As tending in the same direction should be classed the translations into English of Saunier's text-books for schools and workshops, by Mr. Edward Rigg, jointly with myself.

But the exhibits I have selected to illustrate my conclusions to-night are those of the British United Clock Company of Birmingham, as regards the manufacture of the cheap drum clocks (with which American and French firms have flooded the markets because of their singularly low price); and the old and important house of Rotherham, of Coventry, as regards the manufacture of standard types of English lever watches.

Passing to notice in detail the important display of Messrs. Rotherham and Sons in the exhibition, I may say that their exhibit was intended to show the re-organisation that English watch manufacture has undergone during the present decade, and the result is perhaps best shown by quoting two criticisms by foreign experts.

One was delivered by an eminent Swiss writer, who said of the English trade, as represented at the Paris Exhibition of 1878:—"It is complacently asleep in the conviction of having raised limits which its rivals or successors can never surpass." The other criticism is taken from the *Revue Chronométrique*, of November, 1889, and is from the pen of Mons. E. Antoine, one of the Besançon jurors, himself a watch manufacturer of the first rank. He says of this firm, in showing the application of machinery to watchmaking:—"It equals, if it does not surpass, its predecessors in every country." We have here a complete reversal of previously existing impressions, and this should be highly gratifying to every Englishman.

The exhibit was in itself very simple; it consisted of a connected series of pieces of the movement, showing, step by step, the condition of each part as it passed, process by process, from the raw material to the finished work.

Every part of the watch was illustrated in this way, and so arranged as to convey a clear indication of the methods adopted, and in some measure of the machinery employed throughout the whole of the manufacture. In like manner the making of enamel dials, of gold and silver watch cases, and of pendants and bows, were exemplified; but simple as it was, it was readily seen by the jury that they had under their consideration as complete an organisation as could be found in any country. The various branches of watch manufacture were found to be all brought under one direction, and each of those branches had been revised in its methods by the introduction of automatic machinery of the latest type. By a series of photographs it was also seen that they were manufacturers of their own machinery and appliances, and it was elicited by the jury that in their tool-making a regular system of measurements and gauges secured the advantage of interchangeability in the lathes, engines, and general machinery of the place.

I have been able to obtain from Messrs. Rotherham a few photographs taken in their factory, from which I have made slides, which I will presently throw upon the screen to show the aspect of a modern watch factory, but before doing so I will try to make clear the essential difference between the old and the new methods of manufacture. It is generally known that in the very early days of watchmaking the whole of the mechanism was the handiwork of some master craftsman, who designed and fashioned all its parts from crude metals, and even worked up the metals themselves, by his own peculiar treatment, into a condition of special fitness for his wants. This craftsman, with mechanical aptitude of the first order, was of good education and wide reputation, and such workmen were often retained by emperors and princes for the making of costly gifts. Note the conditions we start with here. The whole of the operations are concentrated under one roof and control, with a high level of education in the worker. After this time came the usual evolution, differentiation began, and slowly we find the making of the parts more and more subdivided, and specialists in the various branches combining their work to form the whole machine, resulting in a very great advancement in quality. Further divisions and subdivisions follow, also further raising of the standard of excellence, until the errors of time-keeping fell from five minutes a day to less than one minute a week.

But all this was attended by a greater and greater separation between the workers. Beginning by occupying different houses in a given district, and then different districts in a town, they eventually became distributed over the whole face of the country, until the loss of time in fetching and carrying became from 10 per cent. to 20 per cent of the cost. Even this, however, was not the most serious evil. Absence of control gave rise to the much greater disadvantage of a loss of unity of proportion and of evenness of quality—excellence in one part joined mediocrity in another—this being discoverable even in the most costly watches; and, finally, the impossibility of bringing such a disconnected course of working under fixed standards of reference, or under a uniform system of exact measurement, brought about such a condition of things that at last a point was reached when the advantages of specialisation were balanced by the want of dovetailing in this disjointed and cumbrous procedure. Such was the condition of things up to forty years ago, when these drawbacks gave rise to the desire in many minds to get back the advantages of unity of control without losing the advantages springing from subdivision and specialisation; and this is exactly what has been secured by the new system of manufacture in large factories. The system is fundamentally sound and logical, because it secures the union of these advantages. The twenty odd branches of the trade are once more aggregated under one roof and control, and an extreme subdivision is set up, and the whole fabric linked together and governed by a rigid system of measurement for the size and proportion of every part.

The increased application of machinery, associated with this revised method of manufacture, excellent as its results are, is, one may say, almost secondary in importance to the reorganisation which this re-grouping of the trades admits of; but when the automatic processes are added to this reorganisation, we have the powerful weapon forged which gave the Americans, who early adopted it, a leverage in economic production which threw the old manufacturing centres of Europe for a moment into confusion and panic. The American companies were thus able to develop themselves on a vast scale, and to obtain almost complete control of their own markets before the other countries had time to reform. It is now difficult to dislodge them, although it has long, been evident that with anything approaching equal manufacturing facilities, the old centres would once more invade American markets were it not for the existing heavy prohibitive duties. I will trouble you with one other consideration, as it is important to a full comprehension of the radical difference between the old and new ideas. It has been said that an extreme subdivision is made possible in the factory system ; this involves as its corollary great quantities in manufacture. It has been further said that this specialising of the functions leads to increased excellence, but it has this further advantage that, for industrial purposes, it enables the creation of skilled labour in the least possible time. Take, for instance, the formation of a balance-staff-cone pivot: a lad can be taught to pivot a staff in two or three months in a style that would not be possible under several years' practice in the old order of things, and, from doing but this one thing he quickly obtains a dexterity that surprises, until it is remembered that he has made more pivots in six months than an ordinary watchmaker, in the old way, would make in a lifetime. This has been, I am afraid, a tedious explanation, but I hope I may have indicated the sources of the power that underlie the new machine system, and will proceed to put on the screen the few views I have of Messrs. Rotherham's works.

We have here a general view of the works of Messrs. Rotherham and Sons, they extend in three lines of buildings, some 400 feet in the rear of the roadway. The entrance is very unpretentious. The firm was established in 1750, and is the largest and oldest of the kind in England ; it gives employment to 500 hands.

It should be pointed out that one of the special difficulties in establishing a watch factory is that—until quite recently—it was not possible to purchase the machines indispensable to commence the manufacture. It was necessary to begin by starting an engineer's shop, in which to build up the tools and machinery, and to design these, to make the patterns, and to make a long series of machines, required some years of preparation. This is, then, the initial step, and I will therefore put on the screen a view of one of the tool-making shops of Messrs. Rotherham. Glancing at the interior of the work-room, you will observe it is furnished with the usual appliances of the mechanical engineer, all these are of the best kind, but the special feature of such shops in a watch factory is the series of standard gauges, verniers, and micrometers (which cannot be shown on the screen), for securing a close adherence to the exact measurement, which is a fundamental consideration in all automatic watchmaking machinery. A well-equipped tool-room is also a necessity for keeping the watchmaking plant in good condition.

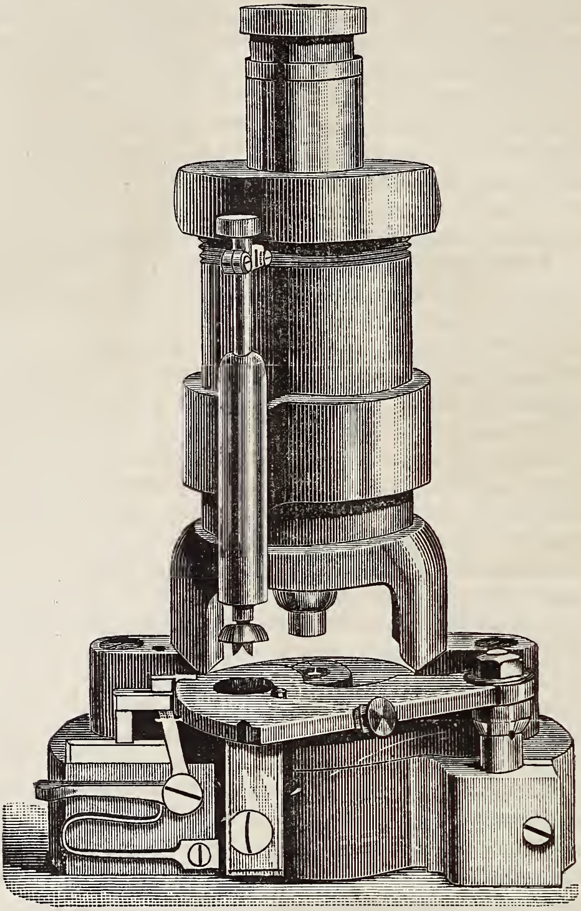
We will now pass to a view of what is called in trade parlance the "plate room," where all the brass parts of the movement are turned and milled into the required form and size, the drilling and tapping of the holes, the steady pinning of the pieces, the planting of the position of each wheel, and the boring out of the recesses to receive the jewel holes.

The parts are received here from the press-room, where they have been stamped out to a given shape, and are here finished ready for gilding.

Girls are largely employed in these operations, as the machines, when set up to measurement by the foremen, are rendered wholly independent of the skill or judgment of the worker. Quickness, care, and cleanliness being the only requirements, gauges, verniers and micrometers are *de rigueur*, to check wear and tear of cutter edges and points. Fines are imposed if anyone is found working without a periodic testing of their work by the standard. An independent office examination of the pieces when completed gives a further check to these precautions. This is one of the strong points of a factory organisation.

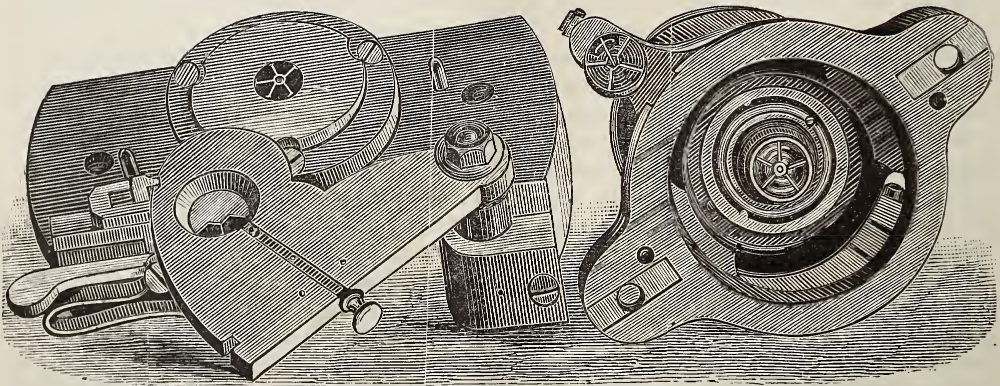
It is desirable to note here that an essential difference between the old and new methods shows itself at this point. There is no roughing

FIG. 1.



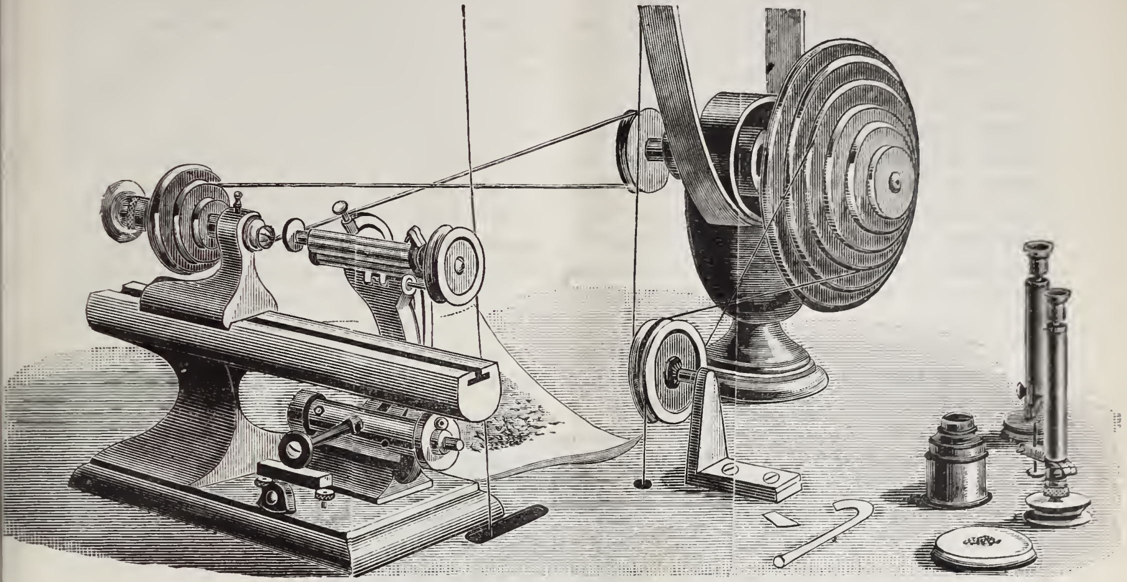
SUB-PRESS WHEEL-SHAVING MACHINE.

FIG. 2.



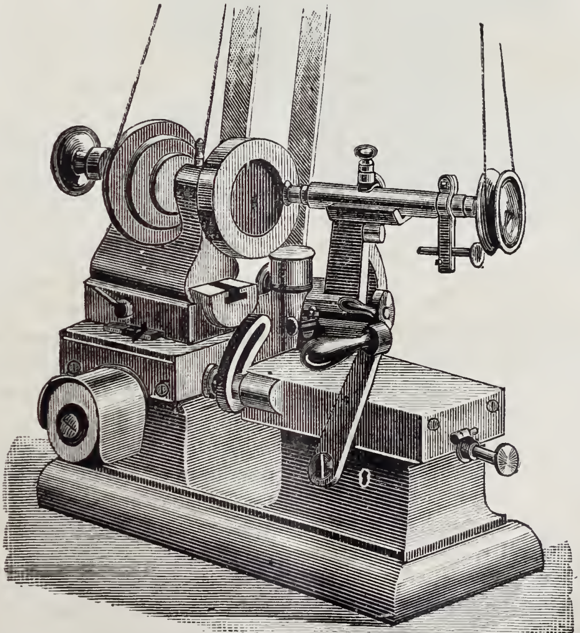
PORTIONS OF THE SUB-PRESS WHEEL-SHAVING MACHINE.

FIG. 3.



BALANCE-STAFF RIVETTING.

FIG. 4.



CONE-PIVOT POLISHER AND SHAPING.

the part out somewhat nearly to its right proportion, and then passing it on to another workman to re-make it smaller, to re-fit it, or to shorten it to right height and length, thus practically travelling over the same work twice. This was the custom formerly; but now a book of drawings of each piece is furnished to the foreman who has to set the machines, and therein a diagram and measure is given for every cut made upon the piece, so that it is reduced at once to the proper dimensions with quickness, directness, and the certainty that it will coincide with the part it is to be attached to. There is obviously a minimum waste of time in this way.

The next view introduces us to a similar group of workers, who are engaged in making the steel work of the watch, that is, the cutting of pinions, ratchets, springs, regulators, studs, and numerous steel pieces of strange shapes which constitute the keyless mechanism. The directness of procedure is again apparent in the fact that, contrary to the older plan, the pinions are at once turned to right height of head, the arbors to the right length between shoulders, and the pivots to right size according to the diagram of measurements furnished to the foreman of the department. No hesitation or mental debating as to proper size is called for; that has all been decided in getting out the original drawing and model from which the measurements are obtained, and action, and nothing but action, is now the order of the day. The general rule of this department is that all finishing operations are done by automatic machines, which only require the operator to feed in the "blanks." The approach of the cutter to its work, the travel, or feed, and the withdrawal of the cutter and the stoppage of the machine, and the completion of the operations, are functioned automatically, leaving the worker free to attend to several machines, or prepare the blanks, or cleanse them. The reason why these machines are not made self-feeding is twofold. Firstly, the minuteness of the parts, and secondly, the need of clearing the centres and surfaces of chucks and cutters after each operation, when dealing with such minute pieces and with such exact measurement.

Our next view shows one of the shops in which the workers are all skilled hands engaged in putting the parts of the watch together, and in timing and adjusting, and casing the movements. Here, apparently, all noise and bustle is gone, and quiet concentration pervades the place. To give an idea of the proportion of these workshops, I may say this one is 180 feet long. Speaking of timing and adjusting, I will mention that Messrs. Rotherham receive the time current daily from Greenwich for this purpose, and that the low, middle, and high temperatures are obtained by refrigerators and ovens placed under ground, and kept within a variation of one or two degrees Fahrenheit all the year round.

In illustration of the kind of economy obtained by the latest labour-saving appliance, let us take the case of a wheel, that most important element in a watch. A watch wheel has four, five, or six arms or spaces, formed to give lightness to it, and these are stamped out in a press, and in cheap watches it is left so, but the act of stamping out these spaces leaves a very rough, torn surface where the metal parts, and hitherto it has been the habit to laboriously file and scrape the surfaces of every arm, web, and boss to give squareness and finish to the object when completed. This required some skill, and is a costly operation of a minor kind: but I will now throw upon the screen a new kind of sub-press or cutting instrument (Figs 1 and 2, p. 370) which is devised to cut just a thin shaving off all the twenty sides and surfaces of a five-armed wheel at one stroke, and the operation, including the fixing of the wheel, is accomplished in less than thirty seconds, and, what is more, leaves the wheel in perfect poise. I have a second slide of this sub-press in pieces to show that it is a somewhat elaborate apparatus. The whole of the parts are fitted by a slow process of polishing when hardened, and which, coupled with the fact that it must be related to the previous punch, which forms the spaces by very exact measurement, makes this a very costly tool.

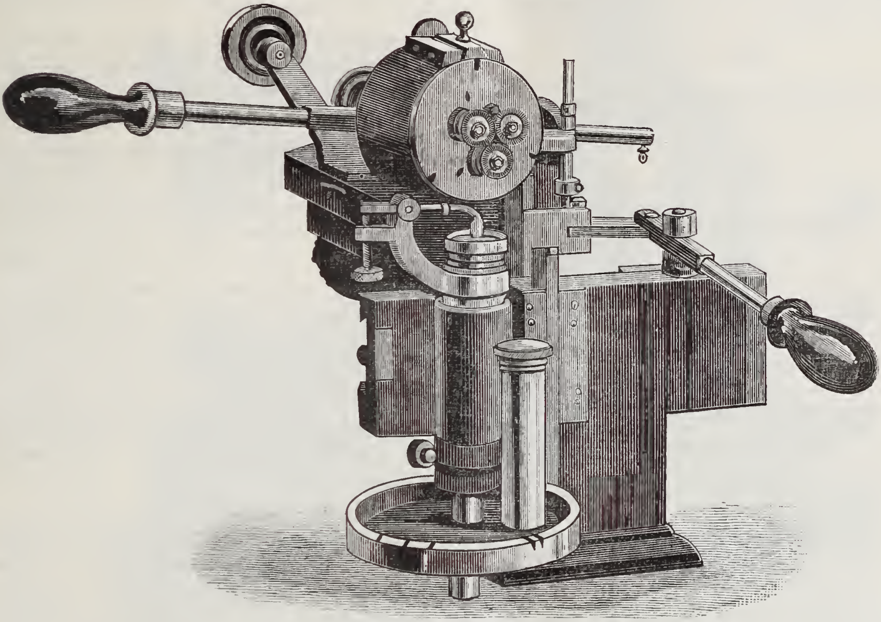
Messrs. Rotherham's is the only place in England where this is practised. I have on the table here a sample wheel, which may be inspected, and which is the eight thousandth wheel so finished without any sharpening of the apparatus, and you will be able to judge of the precision it shows.

The formation of the pivot of a watch is an operation of the first importance, and I therefore place on the screen a photo (Fig. 3, p. 371) of the apparently simple machine in use for this purpose at the factory at Coventry. The principle on which it is built is the recognised one for securing perfect roundness—viz., the work revolving one way and the polishing disc rotating at high speed in an opposite direction. The driving band or gut, it will be observed, is arranged to take off all side pressure on the spindle, and this leaves the "feel" or touch of the worker's hands unimpaired. A device consisting of an inclined plane and roller is added at the base of the machine, which by adjustment will give any desired taper to the pivots. The pivotting is all done to ruby holes of standard sizes.

In illustration of the control in detail made possible in the new system, I put on the screen a machine (Fig. 4, p. 371), the sole function of which is to repair the polishers used on another line of machines, in order to insure uniformity of form when the polishers require renovation from slight distress in wear.

This machine is used to preserve a uniform shape on the cone of balance pivots, and is simply a type of a line of tools existing in a well organised factory, to preserve unchanged the curves and angles of polishers and cutters under the strain of constant use and repairs. Running in a head-stock is a revolving abraser, which may be either a file or emery disc. To this is presented the polisher, mounted in a holder having a circular motion. The radius of the curve given to the edge of the polisher is regulated by the distance it is fixed from the centre of motion of the holding frame, and this distance is an adjustable one.

FIG. 5.



PALLET CUTTING ENGINE.

Perhaps there is no part more difficult to deal with by machinery than the pallets of a lever watch, and especially is this so in the form which it assumes in an English lever, where, for the purpose of being secured against any sort of accident, in use or repair, the slips of ruby are encased in steel; in most cases the difficulty has been evaded by adopting some other form more convenient for the application of machinery; but Messrs. Rotherham were very desirous of preserving this distinctive feature of the English watch, and, after a rather considerable outlay in experimenting, they were able to produce a line of tools which gave excellent results, and I will next show a view of the semi-automatic cutting engine (Fig. 5), for forming this English form of pallet. Here the whole of the nine angles that have to be cut are expressed on a dividing plate, and the blank pallet (mounted on its pallet hole and the two lever pinholes) is cut to these angles, all in absolute relation to one another, in the same manner that the teeth of wheels are cut; the three cutter spindles that revolve are shifted by hand as each cutter is brought into action, but the eighteen stops required and geared together are all moved automatically by the up movement of the cutter handle. The motive in the design of this tool is that the angles cut on the pallets shall not depend upon any angle given to the cutters, but be cut by square-faced cutters easy to produce. Similar devices permit of the polishing of these faces after the insertion of the slips of ruby.

The operations of working the precious metals are necessarily directed to guard against waste, and to this end to do away with filing or scraping, or the making of shavings by turning, or any operations which, by producing dust or minute fragments, result in loss; and further, to do away with soldering the parts together, as this involves filing or dressing in some way the points of junction. The modern method therefore is to treat metals as plastic material, and force them by pressure into the required forms and thicknesses. To illustrate this, I show the formation of a part of a watch case, as made at Messrs. Rotherham's works. The metal is rolled down into a ribbon of given thickness, and then a disc of a calculated diameter is stamped out and then fashioned into a cover as follows:—A disc (Fig. 6) is placed in a cupped die under a strong screw-press, and a stamp of corresponding shape with one blow turns up the disc into the form shown in Fig. 7. A second stamping turns over the edge a little for the snap, as in Fig. 8. A third continues the formation of the snap, and completes it as in Fig. 9. The die used in the foregoing operations has a groove to correspond with the bead required on the bottom, but as yet the bead is not well defined, and therefore a stamp is now used, the contour of which, instead of following closely the outline of the die, bears hard on the points where the beads should be. A blow from this gives the requisite fulness and sharpness to the bead, as shown in Fig. 10. Well and uniformly shaped bottoms are thus produced without soldering. The snaps and outer surface of the bottom are skimmed in the lathe. However necessary turning might be for the snaps, it seems like painting the lily to apply the lathe tool to the already smooth and finished surface of the remainder, but the silver would not yield the particular high polish desired unless the skin of the metal were first removed.

Fig. 6.

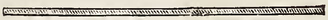


Fig. 7.

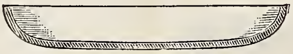


Fig. 8.

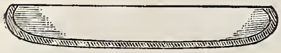


Fig. 9.

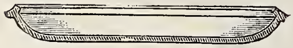
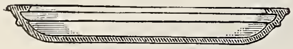


Fig. 10.



Case Bottoms.

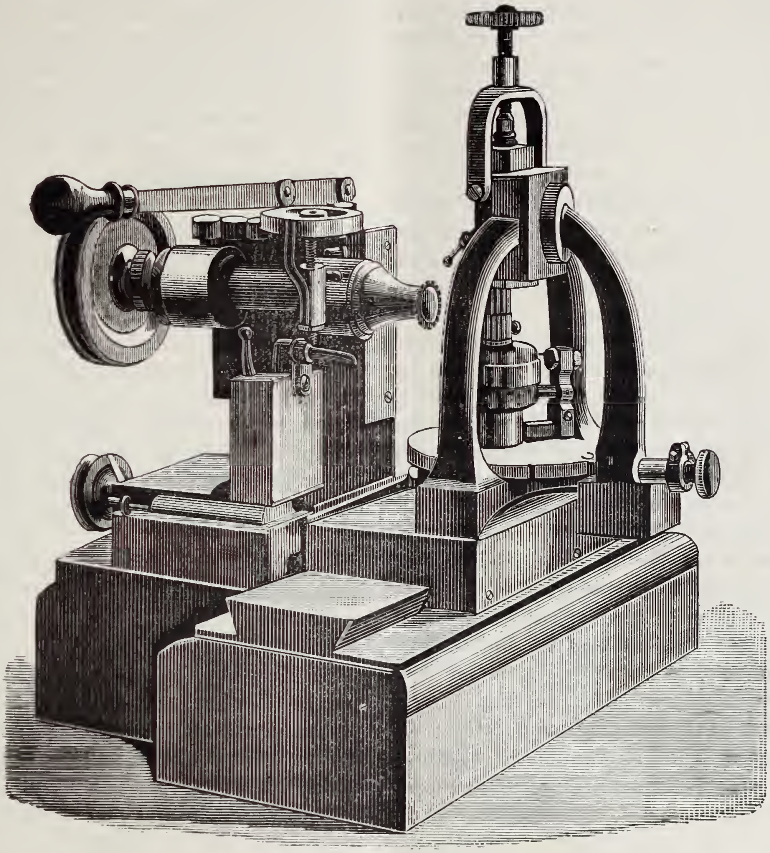
The making of machinery for gold and silver cases is an industry which has kept pace with that for dealing with the watch movement, and I here present a view of a tool designed by Messrs. Rotherham to cut the spaces and recesses into which the knuckles or joints of the case are to be soldered. These spaces are cut by a revolving cutter (Fig. 11, p. 375) at a fixed distance from each other, by means of a dividing plate, and a novel invention is introduced into the machine for securing the truth and accuracy of the depths of the hollows in spite of the twisting of the case under the heat of soldering. This spacing on a dividing engine, and providing for the distortions of metal in soldering, strikes one as refinement in manufacture.

The British United Clock Company is a company formed for the production of cheap lever drum timepieces and alarms, a work hitherto monopolised by foreigners, and in the short space of five years they have successfully checked the importation of these goods. The production of the company has reached 500 clocks per diem. This may appear a large number, but is comparatively trifling compared to the demand.

The best appliances have been laid down, and the factory, although it covers 1,250 yards, and is fitted with engines of 70-horse power, as yet only covers one-third of the ground acquired for future extension. An excellent machine-room is established for making dies and machines, and for repairs. This and an extensive press-room are fundamental requirements in such a manufacture.

A simple recital of a few of the operations in making these clocks may interest those unacquainted with the care and precautions made possible in large works, even where the goods are sold at the singularly low price at which these clocks can be obtained. The wheels have their teeth cut in an engine in place of being stamped out, and the pinions are no longer made from "drawn" pinion-wire, but are also cut in an engine, three cutters in succession traversing each leaf, and they are then subject to a certain degree of polishing. The mainsprings are tested individually after hardening.

FIG. 11.



CASE KNUCKLING.

There is a very neat invention in connection with the winding of the Speedwell alarm. The great wheels of the going and alarm trains are mounted on the winding arbor, one on each side of the mainspring, which serves to actuate both. The wheels are loose, and driven by ratchets and clicks to allow of the arbor being reversed to wind the spring, the outer end of which is attached to the great wheel of the going train. When the alarm is let off, the force of the spring will cause the winding arbor to turn and carry with it the great wheel of the alarm train. But the problem is to lock the spring again when the alarm has run its course. On the winding arbor is a pinion with coarse teeth taking into a segment having a strong butt, which forms the alarm stop. In winding the piece, the first turn of the winding arbor winds the alarm stop, if it is down, and a missing tooth in the segment allows the winding of the going train to proceed in the usual way. This will be made clear by an inspection of Figs. 12 and 13, where the

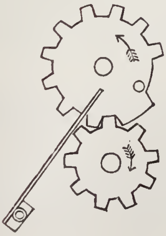


FIG. 12.

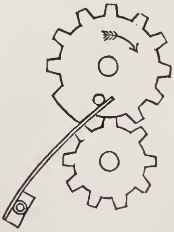


FIG. 13.

wheels and segment are shown as they appear before and after winding. There is, it will be observed, a light spring, which presses against a pin in the segment when it is wound, thus keeping the butt away from the pinion, and ensuring the engagement of the pinion and segment teeth when the alarm is let off. The arrows in Fig. 12 indicate the course of the wheels in winding, and the arrow in Fig. 13 the direction in which the segment will move when the alarm is in action.

In evidence of the thorough-going way in which the company uses every modern aid in furtherance of its work, I may mention that the cases of these clocks and the ornamental dials are prepared for gilding with that peculiar soft grain known as "satin-mat" by the use of a steam sand blast, the process being as follows :—The object is placed in an air-tight box and over the orifice of a pipe containing the sand, the box is then exhausted of air and a jet of sand impinges on the metal, and in a few seconds it has the desired mat.

The energetic way in which the management attacks the difficulties that arise is shown in this fact that finding the brass supplied in Birmingham is not so good for the purpose as that obtainable in America and Germany, because the sulphur from the coal used in annealing injuriously affects the surface of the metal, and shows itself as an uneven surface after being "dipped," it is now preparing plant to make brass with the object of overcoming this defect. Such great energy and enterprise as I have alluded to leads one to understand how, in the short space of less than five years, this company found itself strong enough to venture on competition with the whole world in an international exhibition, and in the opinion of many competent judges did so more successfully than even their Paris award indicated.

There is here a lesson of what may be accomplished by a union of intelligence and energy on the one hand, and capital and commercial capacity on the other, for it must always be remembered that it is not enough to make the goods, but that to distribute them with sufficient rapidity and volume is an essential of success where great producing power is developed.

I hope this hasty glance at these few details may have served to convey an idea of the manner in which watches and clocks are produced by the new method, and that you will perceive that it is not of the nature of a new discovery, but rather a development from our past, and that, as is common in such a case, is attended by an increasing complexity, which requires greater grasp and width of knowledge, and more organising power on the part of those who conduct it. The superintendents, foremen, and sub-foremen of the various departments have not only to know all that appertains to their own proper business, but to deal with the details and fuuctions of the complex machinery set in motion to produce these watch parts, and they have, further, to conduct operations on a much larger scale than has been the custom hitherto. All these requirements demand new facilities for acquiring this special knowledge, and imperatively call for the specialisation of theoretical training in schools equipped with a proper range of teaching appliances.

Our continental rivals have long recognised this fact, even before the advent of this complicated machine system, and the magnificent display of their ten horological schools at Paris last year, testifies to the importance attached to this educational machinery abroad.

It is true that for the first time in our history we had a Clerkenwell school exhibiting side by side with these foreign schools, but the comparison naturally showed our weakness, and the great advantage it is now to the foreigner that he established these training centres a generation before us.

Full details concerning these foreign schools will be found in a small work on "Horology at the Paris Exhibition," which I have now in the publisher's hands.

The necessity for these schools amongst us has become so great of late, owing to the gradual decrease of the apprenticeship system, that we are not without some movement in the desired direction, for a second school has been established in London and one at Edinburgh ; while Coventry has, within the last two years, established one in connection with the technical institute in that city. But in view of its supreme importance this matter moves too slowly with us, and it is to be hoped that the energy and thoroughness which distinguishes the English character will display itself in anxiously promoting and fostering schools of horology.

These remarks bring me to the conclusions at which I have arrived after a careful study of the horological display at Paris.

I find that in comparison with our competitors our position to-day stands as follows :—

1. In chronometry we are supreme.

2. In two or three branches of the clock trade we have a decided lead.

3. In the manufacture of the cheaper kinds of clocks, we show a successful and hopeful new departure.

4. I find that the cost of our best grades of adjusted watches is now as moderate as is the corresponding grade of foreign work, while the gradual elevation shown by the timing records at the Kew Observatory trials testifies that their excellence is being steadily advanced year by year.

5. The records of our deck watches under the severe trials of the Greenwich Observatory, show performances unequalled in the world.

6. As I have shown, in the important matter of watchmaking by machinery we have, during the past ten years, vigorously pushed ourselves to the front rank in quality and organisation, for besides the large factory of Messrs. Rotherham, we have in London those of Messrs. Guye and Company, and Nicole, Nielsen, and Company, and two in Birmingham, that of Messrs. Erhardt and Company, and the English Watch Company, and besides this a new organisation is now arising in Coventry, while only last month Lord Derby attended the opening ceremony of the New Lancashire Watch Company in the village of Prescot, a very old seat of watchmaking.

Now, taking the contrary impressions, I am struck with the, to me, unmistakeable evidence that the following points of advantage which the foreigner appears to have over us is closely, if not solely, related to his having so long possessed those specialised educational advantages we are in the habit of speaking of as technical instruction.

In the first place, then, he is decidedly superior to us in the variety and flexibility of his manufactures, in the wealth of his style, and in the beauty of his decorations.

2nd. In many branches of clockmaking, notably in mantelpiece clocks, where the decorative art comes into play, he holds a decided monopoly.

3rd. In the application of electricity to horology he is considerably more advanced than we can claim to be.

4th. In all that relates to the synchronising of timekeepers, whether by electricity or pneumatically (although perhaps this is debateable ground), I fear we must grant the foreigner a foremost place.

In considering these four points, I venture to reiterate the thought that they are all more or less related to the widened mental condition that comes from especial training in the science and technics of the art. I have estimated that the ten schools exhibiting in Paris have during their existence trained more than 7,000 students, who have passed out and taken positions in the trade as manufacturers, foremen, &c., and thus become centres for extending the knowledge they have acquired.

Consider for a moment the combined influence of this small army of trained minds in strengthening an industry, and what wonder if we find ourselves at some disadvantages in comparison. Still, notwithstanding all this, the review of our position to-day is full of hope.

We see that in timekeeping excellence, and in manufacturing energy and organisation, we may claim much.

Although we have not in this country yet turned our attention to the manufacture of those cheap varieties of watches which make such a show in statistics when comparison of output is made by numbers, yet all this will follow when the organisations that we see planted to-day are developed, as they must be in time. It is useful in this connection to note that the foreigner cannot sell in this country watches of the same grades as those which our English manufacturers devote themselves to making, they are perforce driven to supply us with such goods as our own makers do not attempt to make. It may therefore be assumed that the same consideration will rule when English makers descend to the lower grades and make those other sizes of watches which constitute the bulk of our importations. Moreover, that the success in their respective courses of the two firms specially mentioned to-night ought to incite others to attempt in this country the manufacture of the medium grade of clock now so largely imported for house use, and also a cheaper kind of watch than is yet attempted by Messrs. Rotherham and Son, to stem the importation of foreign goods which yet takes considerably over a million pounds sterling annually out of the country.

Finally, although I have had no startling discoveries to record calculated to strike the imagination of the public, yet the collective development and the improvement in detail shown in so many directions bears witness, I think, to an inventive activity and a manufacturing energy that maintains for the art of watch and clockmaking in this country a foremost position in the horological world, and gives promise of a great extension of these manufactures in England in the course of the next ten years.

DISCUSSION.

The CHAIRMAN said he should like to slightly supplement Mr. Tripplin's remarks on the British Section in the Paris Exhibition before inviting a general discussion on the paper. The Horological Department was a very important contribution to the success of that section, and it was only right to add that the existence of any horological department was entirely due to the energetic and self-sacrificing labours of Mr. Tripplin, who came to him when the committee were endeavouring, under great difficulties, to organise a fitting representation of British industries in Paris, and said he was determined that the British horological industries should be well represented. He brought all the pressure he could to bear on his friends, some of whom were rather lethargic, and at last succeeded in inducing a number of representative men, connected with clock and watchmaking, to come forward, and in the result there was a very scientific and excellent collection of British horology. When it came to the appointment of jurors, it was pretty evident that there was no one better fitted than Mr. Tripplin to represent this country in horology. He had the facility of speaking French, which was very essential, and he took a prominent part in the work of the jury, not only in obtaining awards for our own country—which was not the proper business of a juror—but in insuring that proper consideration should be given to the merits of the different countries, and by seeing—which was the function of the juror—that the representatives of his own country were not overlooked. Several points in the paper suggested discussion, such as the amount of machinery which could be usefully employed in the construction of watches, and how far we were following other countries, especially America, in the application of machinery for such purposes, and to the different grades of watches. He did not quite agree with Mr. Tripplin and his implied disparagement of cheap watches, because it was of great importance to a poor man that he should be able to procure a reliable timekeeper, and for that they were greatly indebted to the energy of American manufacturers, as was shown some time ago in the paper by Mr. Waldo on the Amercan watchmaking industry.

Mr. HARRISON said Mr. Tripplin remarked that England was behind her foreign competitors in the matter of synchronising clocks, but, as some present knew, a good deal had been done in that direction, and a good deal more would have been done but for the action of the Postmaster-General, who insisted that £15 should be paid per year for every clock synchronised according to Greenwich time. Last year he paid his £15 for the use of the current, and proposed to employ it for synchronising a number of clocks; but the Postmaster-General said he did not know whether that current was used for one clock or whether it was utilised to synchronise 500 or 5,000, and it could not be permitted, unless they got £15 for every clock synchronised. Forty years ago he attempted to do the same thing for the International Telegraph Company, and partially succeeded, but partially was not enough. The mode now adopted was a simple piece of mechanism put in any ordinary clock, and that could be made to synchronise all clocks by Greenwich time. Some years ago he set up a clock at the Horological Institute, when Mr. Cole and Sir Edward Beckett Denison (now Lord Grimthorpe) said that was the thing required.

Mr. SAMUEL JACKSON said he accompanied Mr. Tripplin to Paris, to place the exhibit of the British Horological Institute there, and he felt personally grateful to him for the paper he had read. Although he had referred to two firms only, they were the most prominent, commercially, in this country; but the illustration given in no way touched Clerkenwell manufactures—the watches of precision, and scientific instruments. Still it was a commercial question, as well as a scientific one. Mr. Tripplin had made it clear to all unbiassed minds that the greatest honour was due to the British Horological Institute, of which Mr. Tripplin was Vice-President, and in representing which institute he went to Paris. But for that institution there would have been no watchmaking exhibit there of any value with the exception of the Rotherham firm and the Birmingham factory; but the finest exhibits were from members of the institute, which also paid the expenses attending the establishing of Mr. Cole's School of Horology. That institute was a valuable institute long before technical education was spoken of, and it was unlike the schools by which their foreign competitors had been enabled to go ahead, having no public subsidy. It was established by men like Mr. Glasgow, Mr. Jones, and himself, working watchmakers, who had to depend upon their own exertions to support and maintain a technical journal, which had now been done for thirty years. It was a public work which he thought Englishmen might be proud of; but now, thanks to the City Guilds and the Goldsmiths' Company, they were endowed to the extent of £300, had two professors and thirty-five students, and they were continually turning out an army of expert and scientifically trained men, thus insuring the high character of watch manufacture.

Mr. BEDFORD (Waltham Watch Company) congratulated Mr. Tripplin on his paper, and said the photographs of the Rotherham Company's factory almost made him think he was at Waltham. He agreed with the remarks of the chairman, and regretted that Mr. Tripplin had not given his company the credit which he thought was due to them. Machinery in watchmaking, carried right through the manufacture, was hardly known in Europe until it was shown in the Philadelphia Exhibition, and M. Favre-Perret, the Swiss Commissioner, was the first to raise the note of alarm when he came back from America. He called together the Swiss manufacturers, and told them the perilous position they were in, and this was the starting point of the revival in the Swiss manufacture. The English, however, did not take the hint, and the second note of alarm which impressed itself on the English makers was the Waltham Company's exhibit of machinery at the Inventions Exhibition. Mr. Hewitt, manager of the Prescott factory, when he was in America, was received with courtesy by the president of the company, and conducted over the works, and on his return visited him (Mr. Bedford) at his offices in London, and spoke of his desire to obtain a plant which was then for sale in America, which, however, was afterwards sold to another company. He had the best information, however, that the Prescott factory would be largely supplied with American machinery from Waltham. Mr. Tripplin had referred to European watchmakers being handicapped in supplying the American market by the heavy duties, but he really thought the less said about that the better. How was it that for fourteen or fifteen years his company had been in England selling watches in competition with English and Swiss makers, although they had to pay duty on the steel and other raw material which they imported, which, however, was not of much importance. The great unit of manufacture was labour; they had nearly 3,000 hands at the factory, and their pay roll was about £30,000 a month. If free trade was introduced into America the price of clothing and nearly everything the labourer had to buy would be immensely reduced, and the wages would be probably reduced fully one-third. If then their pay roll were reduced from £30,000 to £20,000 they would be in a very different position. At present, while the total British exports amounted to something like 240,000,000 or 250,000,000 annually, these of the United States were only 25,000,000, and that was not because their labour was inferior in any way, it was simply on account of the high rate of wages owing to protective duties. He was a freetrader, unlike many of his countrymen, knowing that if freetrade were adopted the flood-gates would be opened for the exports of the United States, not with Great Britain only, but with the Colonies and every part of the world; and America would become the keenest competitor England had ever had. He had crossed the Atlantic thirty or forty times, and in his intercourse with merchants going to and fro he found they always admitted, when they had investigated matters in the United States, that the import duties, instead of being a disadvantage to Great Britain, were the reverse, and that the longer the States stood by protection, the better it would be for the British manufacturer. He gave evidence before the Select Committee of the House of Commons on the Trade Marks Act, and did all he could for the protection of the British watchmaker, and to denounce the importation of watches here which were palmed off on the public as being English made. He considered that such dealing was a fraud, and that every watch movement coming into this country should bear the mark of its origin upon it. He should always do all he could to assist the British manufacturer in securing honest and fair trading.

Mr. GOODING (Messrs. Rotherham and Co.) said it was hardly correct to say that the English manufacturers first recognised the necessity for machinery at the Inventions Exhibition. Mr. Bedford knew enough of the time required to establish such an organisation, as had been shown on the screen, to know that Messrs. Rotherham must have commenced much earlier than that. It was true that American companies sold watches in this country, but as had been remarked in the paper, they sold a class of watch which the English manufacturer did not attempt to make, and they did not sell in any quantity the grades which were made in England. The Swiss importations in America had risen during the last few years by leaps and bounds, and factories were established in Switzerland for the express purpose of supplying the American market, thus showing that, when similar appliances were introduced here and there in the old centres, they were able to compete successfully with the Americans, even on their own ground. He inferred from a remark of Mr. Bedford that he intended to convey that England was dependent upon America for watchmaking machinery, but such was not the case. At Messrs. Rotherham's factory about 5 per cent. of the machinery was American, but the remaining 95 per cent. was not only manufactured but designed by the firm, and completely departed, in important particulars, from the American practice. The same claim was made for priority in the application of machinery, but the Swiss indignantly denied it. He saw and conversed with M. Favre-Perret on his return from Philadelphia, and though it was true he raised a note of alarm in order to quicken the minds of his countrymen, he did not consider that the Swiss industry was really imperilled. They were handicapped by the dispersed and disjointed state in which the machinery in Switzerland was at that time being worked, and he vigorously pointed out the need of aggregating it under one management, and the great economy resulting from such centralisation; but the moment that deficiency was supplied they were again able to come to the front. Even if American wages could be brought down to the rate in the old countries, which was very doubtful, there was still the advantage on the side of the Swiss of having a large army of trained labour. On the whole, therefore, he would repeat that the American watch, as sold in England, was a thing which the English, French, and Swiss did not make; and it therefore found a certain sale, as filling a gap in the public demand. The recent introduction of machinery here would fortify the position of the English manufacture relatively to the American, and probably the importation of American watches would soon be checked. Five English factories had been started, and were, more or less, on their feet, and on the whole, therefore, he could echo the hopeful tone with which Mr. Tripplin concluded his paper.

Mr. **Fisher** said he should almost have gathered from Mr. Bedford's speech that it was time for the English to give up watchmaking to the Americans entirely, but he could not concur in that view. He had been to America and had seen their factories, but he came back still nursing the idea that the Britisher was not quite played out yet. Every praise was due to the Americans for the energy they had displayed, particularly the Waltham Company, but there were other people who possessed equal energy, and he thought an Englishman was about as good as any one else, especially if he would get rid of that self-complacency which sometimes landed him in a difficulty. It was quite true that a large proportion of their own machines and tools had been purchased in America, because when a factory was started it was necessary to make it pay almost immediately, and for that purpose it was necessary to get things forward, and, therefore, tools and machinery were purchased in the best market, which happened to be America. The company in which he was interested purchased some tools there, but now they were established and could produce things equal to anything in the world, they were making their own tools and machines, and not only so, but they were designing them and improving upon them. Five years was nothing in the establishment of a manufactory of British clocks and watches, and in the course of ten or fifteen years he held a wonderful development would take place, and the trade would be in as good a position as in any other country in the world.

Mr. **Tripplin** said it was quite true that the success of the Paris Exhibition was in great part due to the school of the British Horological Institute, and he was much indebted to Mr. Jackson for the warm support he gave him on the Council. He was also grateful to him for having referred to that school more at length. His object, however, had been to point out the most striking features of the British exhibit. In reply to Mr. Bedford, Mr. Tripplin said he was not there to fight with the Americans but to represent the English section. He had, in common with Mr. Bedford, a love for fine watchmaking. As far as American machinery was concerned, he must be excused if he felt rather incredulous respecting their priority, remembering as he did what he knew was in existence in this way at Cluse, in the Haute Savoie, and what he knew of the efforts in this matter by Ingold, Lechot, and Vacheron before the Americans were heard of. He thought Mr. Gooding had answered the other arguments of Mr. Bedford.

The **Chairman**, in proposing a vote of thanks to Mr. Tripplin, said it could hardly be doubted that the country of Harrison and Earnshaw was still capable of taking a good position in scientific horology, whilst it had been shown that we were taking a very excellent place in the commercial branch of the art. The value of international rivalry, friendly, but none the less vigorous, had been amply shown in the discussion.

Correspondence.

ORGANISATION OF SECONDARY AND TECHNICAL EDUCATION IN LONDON.

I very much regret that my friend Mr. John Philipson should consider that my remarks in the least detracted from the merit of his exertions in promoting technical education. He was not present at the reading of Professor S. Thompson's paper, therefore did not hear what I said, and, I think, has doubtless unintentionally put a construction on my reported remarks that I did not intend, and has thus founded his statements and arguments on a misapprehension.

It was during repeated conferences with General Donnelly, about the year 1872, in working out his (I think) original idea, that students could be examined in subjects pertaining to the industries they were learning, that I was led to think that, if they were to pass a successful examination, it was desirable that there should be systematic scientific teaching. With that idea, I visited Paris in 1875, with Mr. G. A. Thrupp, our object being to witness the teaching in Paris.

We next year established a technical class in St. Mark's-buildings, Grosvenor-square, on the committee of which for many years I acted as chairman, and he as honorary treasurer. I am glad to hear that technical classes have been carried on in Newcastle and Derby for 30 years, doing good in a quiet way, but I do not think they were known to be in existence by dwellers in London. I have not desired to claim any exclusive credit for advancing technical education, nor do I consider that my remarks can be so interpreted. But I cannot help thinking that the action taken by my firm 21 years ago, in placing Mr. J. Robertson (the gentleman I referred to), for six months' training under the most experienced of the Paris technical teachers connected with the carriage building industry there, may have had some little influence in planting the system in England, as for some years he was the chief teacher at the three flourishing technical classes in London, had some hundreds of young men under instruction, preparing them for the annual examinations, at which many of them passed with honours, carried off the best prizes, and were there trained to carry on their avocation with greater care, skill, and success.

I believe that the first technical lecture on carriage construction, in England, was the one I delivered to the teachers and students of the St. Mark's class, on October 1st, 1877, of which I send you a copy. You will there find that I predicted the rising of skilled and competent teachers from such classes in the future, and this has certainly come to pass, for the present excellent successors to Mr. Robertson, all trained in his classes, are now doing good work as teachers in the London classes. Hundreds of students have passed through these London classes, and some have probably been teaching in provincial classes, what they learnt in London.

Since the year 1864, the Coachmakers' Company has been offering prizes for drawings of various kinds, competed for annually, but it was while I held the office of Master of the Guild, in 1874-5, that a fresh effort was made in the encouragement of essay writing, when a prize of twenty guineas which I offered for the best treatise on "Body Making," was awarded to Mr. James Brown, of Bath. My brother succeeded me as Master, and offered a like amount for the best treatise on "Underworks of Carriages." One of the conditions was that these essays were to be used as a foundation for text-books, and that the manuscript and copyright should be the property of the Company, with a view to future use Although some of them have been printed, I do not think the copyright has ever been legally transferred to those who were permitted to print them as a business speculation. In various years a sum of about £150 has been paid for such treatises by successive Masters and the Company.

No complete set of text-books exists, covering the whole of the carriage building industry; but the Institute of British Carriage Manufacturers is anxious to place such within easy reach of examiners, teachers, and students.

On looking over the advertisement of the eleven text-books on various branches of carriage construction in the last number of the *Journal of the Society of Arts*, I find nine have been published by five different publishers in London, and two in Newcastle. I believe this is the first occasion I have seen such a list in print, giving information to teachers and students as to where they can be obtained.

Quoting our friend Mr. Philipson's words in his published letter, he writes, "One of the greatest stumbling blocks to success are the absurd questions frequently put by examiners;" and suggests that a provincial examiner shall in future be coupled to the London one to prevent his doing wrong. If this is desirable with a man of mature years and experience, does it not seem still more desirable that the present text-books (or prize essays, as I prefer to call them), which have mostly been written by young men, should be criticised, revised, and edited by men of experience, representing the practice of various parts of the country, and so brought into such a condition that the majority of students can understand their meaning or teaching, for he writes at the end of the same paragraph—"Technical names vary in different localities, and in many cases students have failed because they did not understand the question."

I think the two paragraphs I have extracted from his letter, fully justify the explanations I have to offer in reply. GEORGE N. HOOPER.

General Notes.

FANMAKERS' COMPANY.—The third competitive examination of fans, fan leaves, and fan sticks, and designs for the same will be held by the Company of Fanmakers at Drapers'-hall in May next. Prizes are offered to the value of £250, divided under classes from A to H. Particulars and rules for the competition can be obtained from the Clerk of the Company, Guildhall, E.C.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

MARCH 12.—SIR DOUGLAS GALTON, K.C.B., D.C.L., F.R.S., Vice-President of the Society, "The Chemin de Fer Glissant, or Sliding Railway." Sir FREDERICK BRAMWELL, Bart., D.C.L., F.R.S., will preside.

FOREIGN AND COLONIAL SECTION.

Tuesday afternoons, at Five o'clock:—

MARCH 18.—JAMES W. WELLS, M.Inst.C.E., "Brazil."

INDIAN SECTION.

Thursday afternoons, at Five o'clock:—

March 13.—W. R. ROBERTSON, "Agriculture and the State in India." SIR CHARLES TURNER, K.C.S.I., will preside.

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock:—

MARCH 11.—JAMES ORROCK, R.I., "The Claims of the British School of Painting to a thorough representation in the National Gallery." Sir JAMES D. LINTON, P.R.I., will preside.

[Pictures by illustrious English masters whose works are not included in the National Gallery will be exhibited by Mr. Orrock.]

CANTOR LECTURES.

Monday evenings, at Eight o'clock:—

A. H. CHURCH, M.A., F.R.S., Professor of Chemistry in the Royal Academy, "Some Considerations concerning Colour and Colouring." Three lectures.

MARCH 17, 24, 31.

POPULAR LECTURES.

Saturday afternoons, at Three o'clock :—

Professor VIVIAN LEWES, "The Atmosphere." Four Lectures.

LECTURE I.—MARCH 8.—The physical history of the atmosphere, and how it was first discovered that it had weight. Its probable extent and the phenomena on which such calculations are based. The discovery and demonstration by Lavoisier of the composite character of the atmosphere. How the proportions in which oxygen and nitrogen are present in air can be determined. Air a mechanical mixture of the gases composing it, and not a chemical compound.

The regulations for admission will be the same as for the Cantor Lectures, each member having the privilege of admitting a friend.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MARCH 10...Victoria Institute (at the HOUSE OF THE SOCIETY OF ARTS), 8 p.m. Sir M. Monier-Williams, "The Monism, Pantheism, and Dualism of Brahmanical and Zoroastrian Philosophers."

Surveyors, 12, Great George-street, S.W., 8 p.m. Mr. T. W. Wheeler, "Betterments."

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Major-General Sir Frederic J. Goldsmid, "Lieut. H. B. Vaughan's recent Journey in Eastern Persia."

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Rev. Canon Benham, "Beginnings of Modern Europe." (Lecture I.)

TUESDAY, MARCH 11...SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m. (Applied Art Section.) Mr. James Orrock, "The Claims of the British School of Painting to a Thorough Representation in the National Gallery."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. G. J. Romanes, "The Post-Darwinian Period." (Lecture VIII.)

Medical and Chirurgical, 20, Hanover-square, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on the following papers :—1. Mr. C. O. Burge, "The Hawkesbury Bridge, New South Wales." 2. Mr. F. T. G. Walton, "The Construction of the Dufferin Bridge over the Ganges at Benares." 3. Mr. G. E. W. Crutwell, "The New Blackfriars Bridge on the London, Chatham, and Dover Railway."

Photographic, 5A, Pall-mall East, S.W., 8 p.m. Mr. John Spiller, "Experiments by Dr. Percy and Mr. George Shaw on the Chemical Phenomena of Light."

Anthropological, 3, Hanover-square, W., 8½ p.m, 1. Prof. Flower, "Exhibition of the Skull of a Carib, from a cave in Jamaica." 2. Rev. James Macdonald, "Manners, Customs, Superstitions, and Religions of South African Tribes"

Colonial Inst., Whitehall-rooms, Hotel Métropole, Whitehall-place, S.W., 8 p.m. Dr. W. Schlich, "Forestry in the Colonies and India."

Horticultural, Drill-hall, James-street, Victoria-street, S.W., 3 p.m.

WEDNESDAY, MARCH 12...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Sir Douglas Galton, "The Chemin de fer Glissant, or Sliding Railway."

Geological, Burlington-house, W., 8 p.m. 1. Mr. W. Whitaker, "A Deep Channel of Drift in the Valley of the Cam, Essex." 2. Prof. J. F. Blake, "The Monian and Basal Cambrian Rocks of Shropshire." 3. Mr. R. Lydekker, "A Crocodilian Jaw from the Oxford Clay of Peterborough." 4. Mr. R. Lydekker, "Two new Species of Labyrinthodonts."

Graphic, University College, W.C., 8 p.m.

Microscopical, King's College, W.C., 8 p.m.

Pharmaceutical, 17, Bloomsbury-square, W.C., 8 p.m.

Cymmrodorion, 27, Chancery-lane, W.C., 8 p.m.

Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m. Annual meeting.

Inventors' Institute, 27, Chancery-lane, W.C., 8 p.m. Discussion on "The Resolutions passed at the Recent International Congress on Industrial Property, and other matters connected therewith."

Patent Agents, 19, Southampton-buildings, W.C., 7½ p.m. 1. Discussion on Mr. Owen's paper. 2. Mr. Lloyd Wise and Mr. Herbert Lapage, "The Argentine Republic as a Field of Invention." 3. Mr. A. P. Jones, "Trade-Mark Practice."

Sanitary Institute, 74A, Margaret-street, Regent-street, W., 8 p.m. Mr. W. Kinninmond Burton, "The Sanitation of Japan."

THURSDAY, MARCH 13...SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m. W. R. Robertson, "Agriculture and the State in India." (Indian Section.)

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Ladies' Sanitary Association, 22, Berners-street, W., 3½ p.m. Mrs. Dowson, "The Responsibility of Women in the Mental Training of the Young."

London Institution, Finsbury-circus, E.C., 7 p.m. Professor Ernest Pauer, "Fashion in Music."

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Mr. Charles Holmes, "Wood Engraving in Japan."

Royal Institution, Albemarle-street, W., 3 p.m. Mr. F. Niecks, "The Early Developments of the Forms of Instrumental Music." With Musical Illustrations. (Lecture II.)

Electrical Engineers, 25, Great George-street, S.W., 8 p.m. Adjourned discussion on the following papers :—1. Mr. James Swinburne, "The Theory of Armature Re-action in Dynamos and Motors." 2. Mr. W. B. Esson, "Some Points in Dynamo and Motor Design."

Mathematical, 22, Albemarle-street, W., 8 p.m.

FRIDAY, MARCH 14...United Service Inst., Whitehall-yard, S.W., 3 p.m. Principal Vet.-Surgeon G. Fleming, "The Shoeing of Horses for Military Purposes."

Royal Institution, Albemarle-street, W., 9 p.m. Prof. T. E. Thorpe, "The Glow of Phosphorus."

Quekett Microscopical Club, University College, W.C., 8 p.m.

Astronomical, Burlington-house, W., 8 p.m.

Clinical, 53, Berners-street, W., 8½ p.m.

New Shakspere, University College, W.C., 8 p.m.

SATURDAY, MARCH 15...SOCIETY OF ARTS, John-street, Adelphi, W.C., 3 p.m. (Popular Lectures.) Prof. Vivian Lewes, "The Atmosphere." (Lecture II.)

Foremen Engineers and Draughtsmen, Cannon-street Hotel, E.C., 8 p.m. Prof. W. C. Unwin, "Objects and Methods of Steam-engine Trials."

Royal Institution, Albemarle-street, W., 3 p.m. Lord Rayleigh, "Electricity and Magnetism." (Lecture V.)

Journal of the Society of Arts.

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FRIDAY, MARCH 14, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

BRITISH SCHOOL OF PAINTING.

The collection of pictures by English masters, lent by Mr. James Orrock, and shown in the meeting-room of the Society of Arts, in illustration of his paper on "The Claims of the British School of Painting to a thorough representation in the National Gallery," read on Tuesday evening, 11th inst., will remain on view until the end of the week. The collection includes examples of works by G. Barret, David Cox, Copley Fielding, W. Müller, Bonington, Phillip, Linnell, Holland, W. Hunt, De Wint, G. Chambers, Vincent, Morland, and other masters of the English school not adequately represented in the National Gallery.

Visitors are admitted on presentation of their visiting cards.

The room will be open from 10 o'clock to 5, except on Saturday, the 15th inst., when it will be closed at 2 o'clock, in consequence of Prof. Lewes's lecture at 3.

POPULAR LECTURES.

Prof. Vivian Lewes delivered the first of a course of four lectures on the "Atmosphere," on Saturday afternoon, 8th inst., and showed how, step by step, our knowledge of its physical and chemical properties had grown. The fact that air had weight was suspected by the early philosophers, but it was not until the 17th century that this fact was conclusively proved by the experiments of Torricelli and Blaise Pascal. The methods by which the extent and weight of the atmosphere could be measured were then given, and it was shown that Wollaston's calculation, based on the duration of twilight, that the atmosphere only extended a distance of about 45 miles from the surface of the earth was only true as regarded air of sufficient density to refract light, and that as luminous meteors were observed at a distance of 200 miles, traces of the air must exist at that altitude. The great epoch in the history of the atmosphere was Lavoisier's discovery of the nature of air in 1774. Air, which up to that time had been looked upon as an elementary body, was now shown to be a composite gas, containing as its chief factors oxygen and nitrogen, and from 1774 up to 1841 a controversy raged as to whether these two elements were present in air chemically combined together, or in a state of mechanical mixture, the discussion being finally brought to a conclusion in 1741 by the exact experiments of Dumas and Boussingault, who showed air to be a mechanical mixture of these gases, containing traces of other gaseous compounds.

THE ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal for 1890 early in May next, and they therefore invite members of the Society to forward to the Secretary, on or before the 19th of April, the names of such men of high distinction as they may think worthy of this honour. This medal was struck to reward "distinguished merit for promoting Arts, Manufactures, or Commerce," and has been awarded as follows in previous years:—

In 1864, to Sir Rowland Hill, K.C.B., F.R.S.

In 1865, to His Imperial Majesty, Napoleon III.

In 1866, to Michael Faraday, D.C.L., F.R.S.

In 1867, to Mr. (afterwards Sir) W. Fothergill Cooke, and Professor (afterwards Sir) Charles Wheatstone, F.R.S.

In 1868, to Mr. (afterwards Sir) Joseph Whitworth, LL.D., F.R.S.

In 1869, to Baron Justus von Liebig, Associate of the Institute of France, For. Memb. R.S., Chevalier of the Legion of Honour, &c.

In 1870, to Vicomte Ferdinand de Lesseps, Member of the Institute of France, Hon. G.C.S.I.

In 1871, to Mr. (afterwards Sir) Henry Cole, K.C.B.

In 1872, to Mr. (now Sir) Henry Bessemer, F.R.S.

In 1873, to Michel Eugène Chevreul, For. Memb. R.S., Member of the Institute of France.

In 1874, to Mr. (afterwards Sir) C. W. Siemens, D.C.L., F.R.S.

In 1875, to Michel Chevalier.

In 1876, to Sir George B. Airy, K.C.B., F.R.S., then Astronomer Royal.

In 1877, to Jean Baptiste Dumas, For. Memb. R.S. Member of the Institute of France.

In 1878, to Sir Wm. G. Armstrong (now Lord Armstrong), C.B., D.C.L., F.R.S.

In 1879, to Sir William Thomson, LL.D., D.C.L., F.R.S.

In 1880, to James Prescott Joule, LL.D., D.C.L., F.R.S.

In 1881, to August Wilhelm Hofmann, M.D., LL.D., F.R.S., Professor of Chemistry in the University of Berlin.

In 1882, to Louis Pasteur, Member of the Institute of France, For. Memb. R.S.

In 1883, to Sir Joseph Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S.

In 1884, to Captain James Buchanan Eads.

In 1885, to Mr. (now Sir) Henry Doulton.

In 1886, to Mr. Samuel Cunliffe Lister.

In 1887, to HER MAJESTY THE QUEEN.

In 1888, to Professor Hermann Ludwig von Helmholtz.

In 1889, to Dr. John Percy, F.R.S.

A full list of the services for which the medals were awarded was given in the last number of the *Journal*.

Proceedings of the Society.

APPLIED ART SECTION.

Tuesday, March 11, 1890; Sir JAMES D. LINTON, P.R.I., in the chair.

The paper read was—

THE CLAIMS OF THE BRITISH SCHOOL OF PAINTING TO A THOROUGH REPRESENTATION IN THE NATIONAL GALLERY.

By JAMES ORROCK, R.I.

The subject of my paper this evening is one which has engaged for years the attention of all lovers of British Art; for the representation of the English School of Painting in our National Gallery is a matter of great public importance.

Before I enter upon the scheme for the righting of our wrongs, with your permission, I will, as briefly and clearly as possible, endeavour to give you the reason why our art ought to be fairly represented not only to our own people but to the world at large. Foreigners, and even our own kith and kin, have constantly twitted us with having "no school of painting;" they have gone farther, and said that, as a nation, we have no artistic taste whatever. It will be very easy to prove that the contrary is the fact, and that we have not only always had a strong artistic feeling, but have actually produced a great school of painting, as well as masters in many other departments of Fine Art.

Our national art reaches as far back as the Runic monuments in stone, and the Celtic designs in metal. Our Saxon, Norman, and Early-English Gothic, and our Tudor Gothic, ecclesiastical and domestic, compare with, and probably excel, in point of beauty and simplicity anything of their kind in the world. Throughout the Middle Ages England was pre-eminent in what was then one of the most important arts, I mean the art of embroidery, and the decoration of stuffs. The treasury of many a foreign cathedral contains specimens of work with English needles which is still unrivalled. We have produced artistic metal work for centuries, and although it is probable that much of it was executed by foreign artists, still our artistic tastes led us to possess it. We have produced great miniature painters—Nicolas Hilliard and Isaac Oliver lived in Queen Elizabeth's and James the First's time; Samuel Cooper during the Commonwealth, and Richard Cosway in Reynolds's time. We have had line engravers of the highest class; Sir Robert Peake in the 16th century, and William Faithorne in the 17th; Flatman, his friend, wrote—

> "A Faithorne sculpsit, is a charm can save,
> From dull oblivion and a gaping grave"

There were Sir Robert Strange and William Woollett in the 18th century, and Sharp and William Blake. William Miller, of Edinburgh, recently dead, was the only man who could translate into black and white the mysteries and subtleties of Turner's water-colours. This inartistic country has had some of the finest wood engravers; the brothers Thomas and John Bewick head the list, Luke Clennell, their pupil, John Jackson and others continued it. To-day we have W. J. Linton, the father of wood-engraving in America, the brothers Dalziel, designers for Goldsmith's work, and before them the classic names of Flaxman and Stothard.

The English mezzotinters, moreover, stand alone in their walk of art. Their names are legion, so I must be content only to enumerate a few. John Smith, who produced the celebrated engravings from Kneller's portraits; James M'Ardell, of whom Reynolds said his mezzotints after his own pictures "would confer immortality upon the painter." Valentine Green, with his successors, Samuel William Reynolds, Charles Turner, and, later on, John Lucas and Samuel Cousins. Then there were John Raphael Smith and his pupils, J. Young, James and William Ward, and a host of others. These men were so perfect because most of them were painters, and gave the painter's feeling and knowledge to their works.

Our artistic taste led us to appreciate and employ the talents of Mabuse in Henry VII.'s reign; Holbein in Henry VIII.'s reign; Sir A. More in Mary's; and Rubens and Van Dyck in Charles I.'s. In Charles II.'s reign Lely and the two Vandeveldes were the chief painters. There were, however, native artists also, who painted for our kings and queens. Nicolas Hilliard, Isaac and Peter Oliver, George Jamesone, the "Scottish Vandyke," and William Dobson, the "English Tintoret;" Robert Walker, Cromwell's painter, and Richard Gibson the dwarf. The foundation of the modern English school dates from the reign of Queen Anne, when Sir James Thornhill was commissioned to paint the dome of St. Paul's. As a proof of our artistic taste it is probable that even now, in spite of the continuous drain for foreign museums and private collections, we have still in this country more magnificent pictures by the great masters than are in all other countries on earth. I mean, of course, in private collections. This can be proved by the seemingly exhaustless mine of art from which the exhibitions of the old masters at Burlington-house have been annually supplied. But, strangely enough, with all this love of art, our rulers have made few efforts to conserve our own native talent, although the example has always been before them in the national galleries of other countries, small States, and even cities. We have a splendid National Gallery of the works of other great deceased artists, but our own school is not thoroughly represented. Had it not been for the munificence of a number of donors, the English school would have had no place whatever.

Foreigners, as I have said, declare that we have "no school;" we answer boldly and truly, but we have the sure and lasting foundation of a school, viz., many masters, each master having a marked individuality, and being therefore capable of forming a school of his own. The proof of this is that one of those masters has formed the most favoured school of landscape of modern times. Is not John Constable the founder and master of the modern French school? Did he not lay down the lines for Corot, Rousseau, Daubigny, Duprez, Dias, and the rest? He has even caused the school he himself made to dilute, by reflex action, our own English art. Constable is still the master, however, and probably will continue to be. Had Turner, Crome, Cotman, De Wint, Cox, Müller, and others of our masters, been as well known as Constable, there would have been a battle of the schools of those great painters. They are, however, our reserves. Another proof that we have always been an art-loving race is that, in addition to storing up pictures by the great Italians, we were the first and, for a time, the only supporters of Cuyp, Hobbema, Ruysdael, and other celebrities of the Flemish and Dutch schools. This accounts for the number of fine examples of those painters we have stored in this country. The fear in reference to our own art is that, before long, the prices of pictures by English masters will reach a very high level, and instead of having them at reasonable, I might say small, prices, we shall have to pay enormous sums. A Romney, for example, a very few years ago, could have been bought for £500 which now is thought moderate at £10,000. It is a fallacy to suppose that any foreign pictures, no matter by whom, have risen so rapidly in price as numbers of the English pictures. The cry is, "Secure the works of foreign deceased masters, for they will never be offered again." The cry ought to be, "Secure fine examples of our own school, for not only will prices soon be prohibitive, but other English-speaking nations, Americans and Australians, will outbid you." Fortunately for us, our British collection, thanks to the patriotic spirit of some princely donors, is rich in the works of several of our great men. We are rich in Hogarth, Reynolds, Gainsborough, Turner, Constable, and Landseer, but this is by no means the case with a multitude of other English masters, and—to the disgrace of the authorities—we have no suitable gallery for the proper exhibition of our national art of painting in water-colour. Of that, however, I shall speak presently.

Having done my best to prove that we do not deserve to be called an inartistic nation, I will now, with your permission, endeavour to advance our claim to a proper representation in the National Gallery. Carlyle takes the liberty to "deny altogether the Frenchman's criticism, that no man is a hero to his *valet de chambre*, or if so, it is not the hero's blame, but the valet's, for the valet does not know a hero when he sees him. Alas, no! it requires a kind of hero to do that." It requires a kind of hero also to know the merits of the great English painters of whom I shall now speak. Hear what the great art analyser and critic says on the subject:—

> "If it be true, and it can scarcely be disputed, that nothing has been for centuries consecrated by public admiration without possessing in a high degree some kind of sterling excellence, it is not because the average intellect and feeling of the majority of the public are competent in any way to distinguish what is really excellent, but because all erroneous opinion is inconsistent, and all ungrounded opinion transitory; so that while the fancies and feelings, which deny deserved honour and award what is undue, have neither root nor strength sufficient to maintain consistent testimony for a length of time, the opinions formed on right grounds by those few who are in reality competent judges, being necessarily stable, communicate themselves gradually from mind to mind, descending lower as they extend wider, until they leaven the whole lump and rule by absolute authority, even where the grounds and reasons for them cannot be understood. On this gradual victory of what is consistent over what is vacillating depends the reputation of all that is highest in art and literature; for it is an insult to what is really great in either to suppose that it in any way addresses itself to mean or uncultivated faculties. It is a matter of the simplest demonstration that no man can be really appreciated but by his equal or superior. His inferior may over-estimate him in enthusiasm, degrade him in ignorance, but he cannot form a grounded and just estimate. It is absurd to tell me that they reprobate collectively what they admire individually. The question is not decided by them but for them; decided by few, by fewer in proportion as the merits of a work are of a higher order. From these few the decision is communicated to the number next below them in rank and mind, and by these again to a wider and lower circle, each rank being so far cognisant of the superiority of that above it as to receive its decision with respect, until in process of time the right and consistent opinion is communicated to all, and held by all as a matter of faith—the more positively in proportion as the grounds of it are less perceived."

This reasoning of Professor Ruskin is constantly being proved to be sound, and I firmly believe, and this after long experience, that in spite, as Burns says, "of a' their colleges and schools," there are probably not a hundred men in these islands whose judgment is reliable, as to the sterling and lasting merits of the work of some of our most celebrated masters, especially in landscape. Most people want a history, and unless this is forthcoming, a consummate work of genius is often thrust aside and denounced as a forgery; when the pedigree is established, as it frequently is, the confessed merit and the price move upwards together. Names are understood, but merit, as Ruskin says, must be taken in faith.

I am not now speaking of expert knowledge, but of that knowledge which alone leavens the lump—in fact, of the knowledge of the connoisseur, which decides the place of the subtle painter for all ages. If this power is so rare, is it to be wondered at that busy officials and careless voters should pass by merit which only few can discern? We must appeal, then, to their faith, as Mr. Ruskin says.

Englishmen, with their broad spirit of liberality and its mixture with the traditional feeling that, in matters of taste and artistic power, they are inferior beings, have always bowed the knee and humbled themselves before foreign nations in matters of fine art. This abject race is, or has been, nevertheless, a nation of colourists, with a pronounced genius of its own, as pronounced as its literature, its military courage, its civilisation. We are descended in a direct line from the Venetians, through the Flemish and Dutch; of course Spain, France, and Germany have also produced great painters, but, in the main, those I have named are the three great schools of colour.

This may not be thought the highest praise, but all great painters, whatever other powers they might possess, have been great colourists; and the secret desire of every painter who uses colours is to be a colourist. Let us hear the Professor again:—

> "All men completely organised and justly tempered enjoy colour, it is meant for the perpetual comfort and delight of the human heart; it is richly bestowed on the highest works of creation, and the eminent sign and seal of perfection in them; being associated with life in the human body, with light in the sky, with purity and hardness in the earth: death, night and pollution of all kinds being colourless."

Again he says:—

> "If colour be introduced at all, it is necessary that whatever else may be wrong, that should be right."

Hence the business of a painter is to paint. If he can colour he is a painter, although he can do nothing else; if he cannot colour he is no painter, though he may do everything else. But it is in fact impossible if he can colour but that he should be able to do more; for a faithful study of colour will always give power over form, though the most intense study of form will give no power over colour. Great power over colour is always a sign of large general art-intellect. To colour well requires real talent, and to colour perfectly is the rarest and most precious power an artist can possess. Every other gift may be erroneously cultivated, but this will guide to all healthy, natural, and forcible truth. The student may be led into folly by philosophers and into falsehood by purists; but he is always safe if he holds the hand of a colourist. As we are, or have been, a nation of colourists, it is something to be proud of, no matter what sneers may have been bestowed upon us, for we possess in our masters the "rarest and most precious power an artist can possess."

Our art, as I have said, is founded mainly on the Italian and Dutch schools; but our insular artistic character lies in our being healthy impressionist painters. All art, we know, is impressionist art, no matter how minute and realistic, but the English adopted for the most part what is technically called a looser and freer mode of expression than most of their predecessors, although there were exceptions, as in Rembrandt, Frank Hals, Velasquez, Rubens, &c.

The English art is like the English man: frank, manly, vigorous, sympathetic, delicate, and above all healthy. He sees nature with a clear and fresh vision, and his own nature is to avoid all that is morbid or mawkish in sentiment. Hogarth, Reynolds, Gainsborough, Raeburn, and Morland, were prominent among figure and portrait painters. They were healthy impressionists and colourists.

When we look into the work of our great landscape painters, whether in oil or water-colours, it is not too much to say that we find in their technique a means of recording pictorial impressions of the truest and sincerest kind, which has never been excelled in its infinite flexibility.

In a word, it is as complete and expressive as anything of the sort the world has ever seen. The colours seem jewelled and afloat as it were in amber, and the handling is as unerring as that of the skilled musician. Our English landscape has been pointedly neglected, especially in water-colours. It is perhaps a sign of its greatness, as the same thing has been in the case of literature and science. Ruskin, whose art study has been general, gives most of his attention to landscape; he is at war with the masses for their blindness to beauty, both in nature and in art. In speaking of the sky he says:—

> "The noblest scenes of earth can be seen and known but by few; it is not intended that man should live always in the midst of them; he injures them by his presence, he ceases to feel them if he be always with them; but the sky is for all, it is fitted in all its functions for the perpetual comfort and exalting of the heart, for soothing it and purifying it from its dross and dust, and yet we never attend to it, we never make it a subject for thought. If in our moments of utter idleness and insipidity, we turn to the sky as a last resource, which of its phenomena do we speak of? One says it has been wet, and another it has been windy, and another it has been warm: Who among the whole chattering crowd can tell me of the forms and precipices of the chain of tall white mountains that girded the horizon at noon yesterday? Who saw the narrow sunbeam that came out of the south and smote upon their summits until they melted and mouldered away in a dust of blue rain? Who saw the dance of the dead clouds when the sunlight left them last night, and the west wind blew them before it like withered leaves? All had passed unregretted as unseen; and yet it is not in the broad and fierce manifestations of the elemental energies; not in the clash of the hail, nor the drift of the whirlwind, that the highest characters of the sublime are developed; God 'is not in the earthquake nor in the fire, but in the still small voice.'"

This eloquence is for art as well as nature, and England's great landscape painting has shared the neglect with nature. Our water-colour painters especially have been uniformly treated with contempt, but not by the art-loving people—oil painters have been their enemies.

Strangely enough, its recognition came from literature—Ruskin devoted his genius to its service — "Modern Painters" was written chiefly to bring forward this Cinderella, and, in spite of the power of her proud sisters, she was chosen to illustrate in "Modern Painters" the varied phenomena of sky, earth, vegetation, the Turnerian light and mountain glooms and glories which the great master had made ready in water-colours. Ruskin's study of art and keen observation of nature led him to take up landscape painting as an entirely new theme. Hitherto it had remained an unexplored region, and he was doubly fortunate to find the mystic Turner for his interpreter. Turner's genius had full play in his water-colours, and we are told by Ruskin, who knew him, that he used this medium for his "intense study of nature."

In the water-colour school of England we have many masters; and, although foreigners have been ever slow to give us our due as oil painters, they have always freely granted us the only place for our water-colours. Our Cinderella has had, despite her neglect, the highest honours which could be paid her; she has had the homage of the most eloquent art critic that ever wrote, she was chosen to illustrate the only work that was ever written on landscape art, and the crystal slipper was presented to her in truth by, perhaps, the greatest writer of poetic prose in the English language. The second honour came from Turner himself, for, as we are told, he selected this medium for his "intense study of nature." All this, and yet we have not even a room for the permanent exhibition of our beloved art! Painters, connoisseurs, and amateurs cannot improve their taste or cultivate their talents, and foreign nations conclude we have "no school."

I may here state a most interesting truth not generally known, but a startling truth nevertheless. The best landscape painters in water-colours have also been the best painters in oil, and for this reason. The practice in water-colour, by the masters at least, has always been pure and direct, and any scraping or lifting of colour to obtain grey lights and half lights is added after the "first intention" work is complete. Turner was the greatest master of all in this technique. He was always inferior, by comparison, in oil. The best oil painters have almost invariably been the most direct and simple, and the value —I may say the visible presence—of the first virgin painting in the works of the best painters, in landscape at least, is clearly seen in the finished pictures. It is the fashion for the ignorant and vain to wave the hand of contempt at the humble water-colour painter when he paints in oil; but Turner, Cotman, Cox, De Wint, Fielding, Barret, Holland, Chambers, Müller, and a multitude of water-colour painters of the highest class, in spite of all this scorn, take to-day the first position. With the single exception of Turner, these celebrated masters are not even represented in the National Gallery. It is true that in the South Kensington Museum there are two noble De Wint pictures, and a magnificent oil Barret, which I myself had the honour of presenting to the Museum, making it a condition that this work in oil should hang near the two others in oil by an equally renowned water-colourists. In the National Gallery we ought to have selected pictures in both mediums by all our great painters, so that we might be able to study our own art. When from time to time I have directed the attention of the chief official of the National Gallery to the desirability of securing at Christie's sale rooms some fine and rare example of one or other of our masters, I have always been met with the reply, "There are no funds." I observe, however, in the official report that in 1863 £10,000 was left for the purchase of pictures for the nation by Mr. Thomas Dennison Lewis; that in 1878, £2,612 was left by Mr. Richard Charles Wheeler; in 1881, £23,104 by Mr. Francis Clarke; and in 1885, £10,000 by Mr. John Lucas Walker; £45,716 in all. Those sums of money might have been left for the purchase of pictures by deceased foreign artists; but if so, how comes it about that several insignificant English pictures have been purchased from time to time out of this money? The funds were, of course, left for the purchase of pictures for the National Collection, and the selection was intrusted to trustees. The only restriction was the other way; Mr. Wheeler directed that the interest from his modest benefaction should be applied entirely to the purchase of works by British artists. I quote an example of purchases which will clearly explain why there are no funds for English pictures. In the annual report, 1885, of the Director of the National Gallery to the Lords of the Treasury, we find the following:—

> "Under the will of the late Mr. John Lucas Walker, the testator bequeathed to the National Gallery the sum of £10,000, to be spent in the purchase of a picture or pictures for the National Collection. The said pictures are to be labelled with the donor's name."

Out of this sum, in the report for 1887 (March 1), we find the following:—£6,580 spent on old masters, all of which we might have done without; and £2,698 for a Walker and a Rossetti. Again, in the report of 1887, we "Purchased out of the Lewis fund" English pictures by Opie, by Samuel Scott, and by Thomas Hudson, in all costing £230 15s. But £650 out of this same fund was paid for an Italian picture of the Ferrarese school. There can be no reasonable objection to our buying as many foreign pictures as our funds will afford, so as to make our collection historically as complete as possible; but we want fine specimens of English art, with no view to a history, but for the benefit of painters, students, and all lovers of national art. The people, from all I have seen and heard, who pay the taxes, make this reasonable demand, and object to the beneficiary funds, amounting to £45,716, being spent almost exclusively on deceased foreign masters to the neglect of our own. The terse answer to the statement that "we have no funds" is easily given:—Devote for the future those funds given or bequeathed by private British benefactors to the purchase of British pictures, and to the accumulation of the best possible collection of native art.

It is important, in attempting to show how our art has been neglected, that we should compare the numbers of British pictures bought with those which have been bequeathed or presented to the National Gallery. I have carefully gone through the numbers in the official catalogue for 1889, and the list is as follows—279 oil pictures have been given to the nation, and only 49 have been purchased, including those in the Peel collection, which had to be bought in the aggregate. In this list of bequeathed and presented pictures I do not include numbers now on loan to many of our country museums and art galleries, but simply those hanging in the National Gallery in 1889. And I do not hesitate to say that those purchases of our masters are in the main unsatisfactory, both as to size and quality. If it were necessary, I could name most of them from memory. I am not here, however, to judge of the past, but to inaugurate a better state of things for the future.

In a pamphlet which Mr. Trueman Wood has kindly placed in my hand, I find that this Society made a laudable effort, as far back as 1847, on the suggestion of Sir Henry Cole. He proposed that the Society should organise an annual exhibition of pictures of an entirely novel sort. They were exhibitions of the works of single men; several were held, but the result was not encouraging.

With all deference to this Society, which thus made itself, as it were, the pioneer on a road we should all like to tread, I do not think the precedent they had at that time set should now be followed. In this hall, where so many valuable suggestions have been made, I should like to express my opinion that the only way to bring about the result we all wish for is to obtain promises of money and pictures from English collectors, and thus at least to bring such pressure to bear on the Government, that they may take the formation of a truly British collection in hand. They might begin by directing that the money left to the National Gallery, and not expressively limited to the purchase of foreign pictures, should be used for extending the collection of English art.

I am glad to say that several large sums have been already promised, and a number of choice works in water-colours. No doubt if suitable galleries were found they would speedily be filled by patriotic donors. As this Society has been the pioneer of not a few of our great national art movements, this is the fitting place to speak as I have spoken to-night. Let us all prepare, then, for the fair representation of selected and choice works of our great deceased painters in oil and water-colours; and, to avoid friction and complication, let us direct our efforts to this and this alone. It is always safer to build up from the past, Reynolds's words are as true to-day as they were a century ago—"The works of those who have stood the test of ages have a claim to that respect and reverence to which no modern can pretend."

Let us urge that the beautiful drawings in water-colour by Turner, including the *Liber Studiorum* itself, together with the noble bequest of De Wint and Cattermole which my friend, the late Mr. John Henderson, made to the nation, be removed to a more dignified and better-lighted gallery than they fill at present, so that they may be seen not by a cellar light but by the calm, clear, silver light which is required to allow their infinities and delicacies to be studied and felt. By so acting we shall encourage others to add to the collection, and convince the nations that we indeed have a school. It is not for me even to suggest where the British school galleries should be; but simply to urge that justice to our own art should at last be done. I would then, ladies and gentlemen, earnestly ask your aid for this great national undertaking, and would appeal to men of letters in particular to help us in rousing the nation to a sense of what is due to those painters who, even in the eyes of the long reluctant foreigner, are beginning to take rank among the great high priests of art.

DISCUSSION.

The CHAIRMAN said he should like first to refer to the statement that there was a sum of £46,000 which might and ought to have been devoted to the purpose in view. Mr. Orrock said he had on several occasions called attention to English pictures which ought to have been purchased, and the reply had always been that there were no funds—a very fair answer if it were altogether true, and if the fund had been properly administered no one would have complained, but, as had been very forcibly stated, that fund had been, with two exceptions, absolutely wasted, because the works purchased had no other merit or value than being simply historical. Now, this method of collecting for the National Gallery was diametrically opposed to the principle which up to late years governed the management, for the first object should be that everything received within the walls of the National Gallery should be fine, and the historical view of art should be relegated to another institution altogether. Another reason given for not collecting English works was that, by waiting a time, donations and bequests would be made by patriotic citizens. But he for one, and speaking for other artists, could not afford to wait. Why were they to be debarred from studying the books and references of their art? And who would give water-colours—in which he was most interested—to be placed in cellars? Would a gentleman like Mr. Orrock, who had passed his life in collecting these splendid works, think of giving them to the nation if they were to be placed in the cellars of Trafalgar-square? His belief, founded on knowledge, was that if the masters whose works adorned the walls that evening had been natives of foreign countries, their pictures would have been placed in positions of the highest honour; but we, with our national modesty, reluctantly admitted them to private collections, and they were never seen within the walls of our public buildings. An appeal was now made to the public to remedy this state of affairs. It was astounding what the public could do if they chose, if they had perseverance, and courage, and a good cause, and there could be none better. He did not wish to overrate the English school at the expense of all others, but in their own department they stood alone, and were worthy of a place by the side of any. An old friend of his, lately deceased, had a most exquisite and representative collection of English works, by Cox, De Wint, and all the other great masters, and he had often said to him, "What are the National Gallery going to do for water-colours? I should like to do something for them." But he was obliged to tell him they were not doing anything, and were not going to, and the consequence was that all his pictures would be sold, when they might have been the property of the nation. He could understand the Chancellor of the Exchequer making an objection if large sums of money were asked for; but the fact was there were men now waiting to present to the nation magnificent specimens of these masters if proper accommodation were provided for them where they could be seen. Students also had a claim. It was not a question whether oils or water-colours were the better; but while enormous sums were spent on the education of students in oil, the students in water-colour, who now numbered thousands, were absolutely starved, when he thought that not only as students but as taxpayers they might fairly demand that their wants should be considered. They did not ask for large sums to purchase pictures, but only for rooms in which to exhibit them, for he was quite sure that if a gallery were founded, before it was finished collections worthy of the nation would be presented. It was for the public to insist that this should be done.

Dr. **Marshall** said he felt some difficulty in discussing abstract questions about art with so many beautiful pictures on the walls, whose very presence was the strongest argument which could be used. Every one must feel that it was ridiculous that these pictures should have to go back again to the custody of a private collection, when they ought to be placed somewhere where they would be always accessible for study and enjoyment. In Edinburgh they had a National Gallery which had a certain dignity and value, possessing some very fine Vandycks, Ettys, and Watteaus, but not by the liberality of the Government, for they had a special grievance, that though they contributed equally with other portions of the kingdom to taxation, they never had a sixpence allowed for the purchase of a picture. It was a great grievance that, some years ago, when one of the finest collections in Scotland—that of the Duke of Hamilton—was sold, though the head of the English National Gallery, and also of the Irish, could make purchases' no representative of the Scottish National Gallery could not attend the sale, because he had not one penny to expend. This grievance, he trusted, would in time be removed, and he would rather speak on the general grievance on which Mr. Orrock had so well spoken. Shortly after he settled in Edinburgh he received a catalogue of a sale of pictures, and thought he would go and look at them, seeing the names of Cox, De Wint, Müller, and other well-known artists; but he did not find even a pretence of an imitation of the work of these masters, and it was evident that the names had simply been stuck on at random. That, of course, was a thing which any dishonest auctioneer might do anywhere; but he found that men in the neighbourhood with whom, from kindred sympathies, he was acquainted—men who were real buyers of pictures, with all the anxiety in the world to know what Coxes, and De Wints, and Müllers were—absolutely did not know whether they were genuine or not. They had never seen pictures by these men, and they said they would give anything for an opportunity of seeing them, and asked where they could see them. He could only direct them to his friend Mr. Orrock, who was always very generous in showing his collection, for he knew of no exhibition where they could be seen. As had been said, between 1824 and 1862, not a single English picture had been bought by the directors of the National Gallery; but that was just the period when they should have been bought. Practically, the great period of English art was from 1760 to 1860 and during the last quarter of that period the directors of our art gallery should have been garnering in the finest treasures of that harvest. Mr. Orrock had not inherited these beautiful pictures; he had probably bought most of them just after the time he had mentioned, so that all these, and others in the possession of other collectors, had been in the market available for purchase; and probably, when we did begin to buy, we should have to pay £10,000 for what could have been obtained for £2,000. It was for the interest of all that the great tradition of art should have no break. Art, like science, and everything valuable, was a matter of accumulation. A man to be original in anything—science or art—must, in the first instance, gather in the best of what had gone before. There were no sudden jumps or breaks in art; the great men who originated a school were those who had imbibed and assimilated the finest of what was before them. Now the period when the great men were gathering and learning the great traditions of modern art was just that period from 1760 to 1824; our great painters were then ardent students of the Venetian and Dutch schools, and we were, by the works of those men, imparting the greatest thoughts of the greatest artistic intellects of the world. That was just the time when those men should have been brought in contact with the rising artistic mind of the nation, but just then there came this break: their works were not purchased, and artists had not the opportunity of seeing them. It had been said on looking round the walls of the Royal Academy in Edinburgh, that hardly anyone there represented seemed to have ever looked at a picture except his own or his fellow academicians; and something similar might be said of the exhibitions in the Royal Academy in London. The pictures seemed to be produced by men of ability, who were—in the wrong sense of the term—self-educated men; who had no knowledge, really, of the great traditions of art which Turner, Cotman, and Crome so greatly followed. He did not say this was so as a fact, but it was the impression produced by looking at the pictures. Artists in Edinburgh had deplored to him that they had not the opportunity of seeing these great landscapes. No doubt they could go back to the Venetian and Dutch masters for themselves, and, if they were great enough, might profit by that study; but it was a good thing that those traditions should be adapted for them by men of their own race, and brought nearer to them by people of similar surroundings. These pictures had a message which the majority of those in the National Gallery, with all their merit, would never convey to the great majority of people who loved pictures without professing to know much about them. They were the utterances of our own people; and just as, without undervaluing Homer, Virgil, or Molière, we rejoiced in Shakespeare, Milton, and Burns, so we might feel, without depreciating others, that these were our own pictures, and that they spoke to us as others did not. It was in the interest, therefore, not only of artists, but of the whole nation, that such a collection as this, and many others, should be within the reach of the public.

Mr. CUTHBERT QUILTER, M.P., said as a member of the House of Commons, he blushed for the assembly to which it was supposed to be an honour to belong, when he thought of the utter indifference which it showed to the claims of art. Almost any crotchet or fad was certain of an attentive hearing; but let any honourable member advocate the claims of art, whether painting, sculpture, engraving, or any other branch, his audience would be very small, and very likely he would be snuffed out by the first Minister who got up, saying that there were no funds available. He hoped, however, from a meeting like this and from other signs, that that state of things was coming to an end. The sensational prices which private individuals had recently been giving for certain works of the old English masters had at last even woke up John Bull, who was very slow to appreciate anything at his own door, and which he could purchase without a large outlay of coin. These sensational prices had influenced a great many people who cared little for art; they were astonished to hear that a picture of the English school had sold for £17,000, and it begun to strike them that there might be merit in that school after all. If some action were not taken before long, these pictures would be lost to England, and our cousins and relatives beyond the seas would possess them. It was hardly possible to believe that so many years should have passed, and that the only treatment afforded to those great artists with whom he had been brought up, such as David Cox, De Wint, Copley Fielding, Müller, Holland, Cotman, and others—was to bin their productions in a cellar in much the same way as old port or sherry. He trusted some organised effort would be made before long to influence the Legislature in this direction, and even in the House of Commons he believed there could be found "ten righteous men" to support a claim for recognition of national art, and a provision for housing it worthily. Those who had hitherto advocated the claims of art had in the main been somewhat faddists, worshippers of some particular school, who believed that nothing was good which came more than 20 miles from Bologna or Sienna, and that it was necessary to go to Venice or Naples to appreciate art, and that any man who had not been in Florence was incapable of appreciating anything. But education was spreading, and he hoped the outcome of that meeting would be some organised, practical plan of bringing about what they all desired. Perhaps the society of which he was the hon. treasurer, that for the advancement of art, now in its second or third year, might do something; he did not know how they could advance art better than by obtaining a recognition that the works of the English schools were entitled to a separate room in a suitable building. He had no fear for the money; it was a bold thing to say, but he believed that collectors loved art not only for the pleasure it gave themselves and their friends but for its influence on their countrymen, and especially on those of the poorer classes, into whose daily lives of toil the sight of such things brought so bright a gleam. He believed large numbers of pictures would be offered, and indeed that they might suffer from a plethora of such gifts. He had heard that one of these large-hearted collectors had just made a very munificent offer, but he had not heard in what spirit it had been received. In the first instance, he thought a fund should be started to be applied to the purchase of works of art, and he ventured with some diffidence to differ from Mr. Orrock, in suggesting that the interest of the fund should not be solely devoted to the purchase of the works of deceased masters. He looked with envy on our French neighbours, who possessed in the Luxembourg a place where every one who could paint a good picture was certain of finding a home for it; but here an artist had only to paint a great picture, and it was almost impossible for him to do anything with it at all. He must be a brave man who cared to risk twice the painting of a picture of large size, dealing with a heroic subject, in this country. Yet people were wont to say "Why do you spend all your time on pot-boilers?" forgetting that, even under the enlightened rule of the London County Council, the tax collector still came round, and that the claims of wife and family could not be entirely ignored. What inducement was there to paint for fame, when a great picture might be kicked about from pillar to post, with a remote chance, perhaps, of its finding a home in some Colonial gallery. You would be left with it on your hands, and have to put its face to the wall, and explain to any kind friend who came in that it was the great picture on which you had spent perhaps the two best years of your life. Would it not be possible to combine a gallery of the works of the living masters as well as of those deceased? He was quite aware of the difficulty of selection, for even the decisions with regard to the Chantrey bequest were not always unquestioned; but a committee of selection might be formed, not composed mainly of those who painted or wrought themselves, but of those amateurs and lovers of art who could have no other interest whatever than to select pictures for purchase which were worthy of a place in a national collection.. He trusted that one and all would work with a will to bring about a result so desirable not only to those interested in art but to every lover of his country.

Mr. P. H. NEWMAN said he was pleased to see that the Society had taken up this subject, one which was deserving of having a section devoted to it, as it could not be considered as applied art. He hoped that some organised effort would be made by the Society to carry out the views which had been put forward.

Mr. HAITE said he was anxious that some practical outcome should result from that meeting. They were fortunate in having a Member of Parliament present, and he could not but be struck with the fact that while there was comparatively little difficulty in passing the Free Libraries Act, there was an immense difficulty in getting a discussion on art matters in the House of Commons. When the programme was more complete, and the matter had been pretty well threshed out, he believed the object would be attained, either by national expenditure or by gifts from private individuals. There ought to be a collection of national art as distinguished from all others; and he hoped every effort would be made to influence members of Parliament in its favour, so that it might be fairly brought before the House of Commons.

Mr. WIMPERIS desired, on behalf of artists in general, to thank Mr. Orrock for this paper, in which he had given exact expression to their feelings. They had suffered very much at the hands of those who said that English art had no masters, and that if they wanted to paint properly they must go and study in France. Turner was fairly represented in the National Gallery, and so was Constable and one or two others, and if their compeers were equally well represented, they would form such a collection that even foreigners would admit that it was a school of landscape painting which was unequalled in the world; and they would be able to say, "Which do you prefer, the echo or the original voice? to fall at the feet of the grandchildren or of their great progenitor?" His feeling was that he would prefer to have his art first hand, and draw his inspiration from original sources, and if they had such a representation of English art in the National Gallery, so that any intelligent foreigner might go there and see what Englishmen could do in landscape, they would be astonished at the sweet simplicity, purity of tone, and vivid impression of our charming out door English life as seen in the works of David Cox. If they wanted something more vigorous they would find it in Constable, and if something stronger still were desired they might go to Müller; but the Englishmen could certainly match any foreigner, either for delicacy or strength, and English painters, following their own traditions, and dealing with English scenery, with all its varying mode of climate, were in truth absolutely unrivalled.

The CHAIRMAN having moved a vote of thanks to Mr. Orrock, it was carried unanimously.

Mr. ORROCK, in reply, said he did not come there that evening for the mere sake of reading a paper, but to put forward a great issue, and to ask the public to assist in doing justice to English art, which had been so neglected and despised. The two most prominent points in the question were, first, that the sum of £46,000 to which he had referred should have been wasted, as to the great bulk of it, on pictures of saints, and that the other and smaller portion should have been dribbled away on worthless specimens which misrepresented English art in the eyes of foreigners. What the Chairman had said about the cellarage was very much to the point. He knew the gentleman to whom he referred, who, he believed really intended to leave his pictures—which were principally water-colour drawings, for like all connoisseurs of the highest capacity he appreciated that style of art—to the nation, but there was no place to put them. Only the other day he met a friend going to Christie's, and asked him if the rumour were true that he was going to bequeath or present his magnificent collection of water-colours to a certain midland city. He said, "No;" and his wife added, "Certainly not; they were waiting for a room in the National Gallery." What was done to his old friend Mr. John Henderson's pictures? There was an old proverb, "Heaven for climate, but hell for company," and it applied to the heaven and hell of the National Gallery. The heaven, of course, was occupied by the gold-crowned, three-cornered, squint-eyed Byzantine saints, as was but right, but how about the country in the Plutonic regions? It was the country of Turner, for many of his works were there, including his beautiful *Liber Studiorum*, the most unique work of its kind in the world; and other works which embraced sea-scape and landscape of the most exquisite composition by men of the highest possible genius. That was the country in the Plutonic region, but was it reasonable that that magnificent *Liber Studiorum* should be located there? He was not a rich man, but he should like now and then to give a water-colour or two to the nation, but he was not going to have them sent down to the hell of the National Gallery. His friend, Dr. Marshall, was not quite right in saying that he had made his collection in the last 25 years, for it had taken him much longer than that. He remembered when specimens of Cox could have been bought by anybody for £8 or £10, the price of which was now £500 or £600, and so it was with all the English masters. Were they to wait until they became so dear that they could not buy them at all? As Dr. Marshall had said, all art was traditional, and all the great schools were traditional, and he feared that in some instances we were going away from our old moorings, but he hoped English artists would return before it was too late to our own healthy, manly, English work. Mr. Quilter had slightly mistaken him in his reference to purchasing the works of living masters. He suggested buying works of deceased masters because there was not enough money to do both. There was very little for that, but if Mr. Quilter would only rouse those ten righteous men in Parliament, and provide them with funds, he would agree with him by all means. In fact, Mr. Quilter had only added something which he should very much like to have but did not dare to suggest. Let them use the funds they had at present in obtaining selected works of the deceased masters, and in time they might go on to the other, and it would then be seen that English art was about to take an equal rank in the world with its literature, its science, and its civilisation.

FOURTEENTH ORDINARY MEETING.

Wednesday, March 12th, 1890; Sir Frederick Bramwell, Bart., D.C.L., F.R.S., Deputy-Chairman of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Barron, Frederick C., Nervion, Beckenham-grove, Shortlands, Kent.
Chapman, Frank, 5, Tyrwhitt-road, Brockley, S.E.
Clirehugh, Stamford Vair, 14, Ladbroke-terrace, W.
Day, William J., 8, Sydney-villas, Richmond, Surrey.
Fox, James, Hammerfest, 76, Amhurst-park, Stamford-hill, N.
Guy, Charles Williams, Laurel-bank, Anerley, S.E.
Lewis, William Bourne, 15, Victoria-street, S.W.
Rainger, Henry René, 31, Heathfield-gardens, Chiswick.
Rivington, Charles Robert, Stationers'-hall, E.C., Fenchurch-buildings, E.C., and 74, Elm-park-gardens, S.W.
Tyrrell, Avery, Berkin-manor, Horton, Slough.

The following candidates were balloted for and duly elected members of the Society:—

Hederstedt, Henry Burdett, 74, Lancaster-gate, W.
Profumo, Baron Joseph, Parkhurst, Beckenham, Kent.

The paper read was—

THE CHEMIN DE FER GLISSANT OR SLIDING RAILWAY.

By Sir Douglas Galton, K.C.B., D.C.L., F.R.S.

The original design of this form of railway is due to M. Girard, whose name is well-known as that of a hydraulic engineer of considerable eminence. Girard was, moreover, an enthusiastic inventor, and the first idea of a railway on which a new mode of propulsion might be given to the trains occurred to him nearly forty years ago. At that time the hydraulic engineering works of La Jonchère were flourishing under M. Girard's management and ownership, and he was engaged upon constructing and erecting the turbines of the now famous chocolate factory of M. Menier at Noisiel. M. Girard proposed to substitute for locomotive engines on a railway a series of jets of water issuing from nozzles standing up along the centre of the railway track, so arranged that the issuing streams could exert their effect on the underside of the carriages composing the train, and cause it to travel along the rails.

He further proposed to suppress the wheels, and to substitute flat surfaces or bearing-plates, upon which the carriages would rest; these would slide upon rails of a section specially designed to support them, and in order to reduce the friction, M. Girard proposed to separate the surfaces of the rail from that of the bearer by means of a film of water to be maintained between the bearing-plates and the rails.

An experimental length of line which he constructed at La Jonchère, on which there was an incline of 1 in 20, led him to some interesting conclusions, and he was further encouraged by the great interest which the late Emperor Napoleon III. showed in his scheme.

M. Girard considered that the results which he had obtained would justify the application of the system in special cases on a paying basis, and he applied for a concession for a railway from Calais to Marseilles, which was granted to him in 1869, and to this concession a subvention was attached.

But the war of 1870 put a stop to the whole matter, and further resulted in the destruction by the German army of M. Girard's model railway, and in his death on the battle-field early in 1871.

After peace was restored, what remained of M. Girard's works at La Jonchère was sold. Amongst the relics were all the documents relating to the railway scheme, and these were finally purchased by M. A. Barre, who had worked with M. Girard, and a model of the line on a small scale was submitted to the Jury on Railways of the Paris Exhibition of 1878.

For several years M. Barre has been engaged in making further experiments upon, and gradually changing and developing, the original ideas of M. Girard.

A line of 170 yards long on the improved system was established in the late Paris Exhibition. This line had first a downward incline of 1 in 90 for 40 yards, followed by a level of nearly 90 yards, and then an upward incline of about 40 yards at an incline of 1 in 180. Trains were run daily upon this line, but as its length was only sufficient to enable a train to be run backwards and forwards, none of those arrangements could be exhibited upon it which would be necessary in the general working of a railway with consecutive stations, or for transferring a train from one line to another.

The design may be classed under two heads:—

First, the arrangements for supporting the vehicles. These consist of (1st) the bearer or skate affixed to the vehicle; (2nd) the method of supplying the film of water to the bearer or skate; (3rd) the rail.

Secondly, the method of propulsion intended to supersede the ordinary methods of traction. This consists of (4th) the arrangements on the vehicle for receiving the water of propulsion; (5th) the hydrants for propulsion; (6th) the arrangements for catching the water after it has served its purpose.

The diagrams which illustrate this paper (pp. 396-7) have been supplied by the courtesy of the Editor of *Engineering*.

I.—ARRANGEMENTS FOR SUPPORTING THE VEHICLES.

(1.) *The Bearer*, or skate, or slide. Of these there are four to six attached to each carriage, corresponding in position to the wheels in an ordinary railway carriage.

M. Girard's original proposal for these is shown in Figs. 1, 2, 3. This has been altered by M. Barre, and his revised arrangement is shewn in Figs. 4, 5, 6.

The bottom of the skate is rectangular, 22 c.m. wide by 44 c.m. long (say $8\frac{2}{3}$ inches by $17\frac{1}{3}$ inches), that is to say, it covers a total area of 968 square centimetres, or about 150 square inches. It is, however, grooved or indented so that the actual surface resting on the rail when the skate is at rest does not exceed about 84 square inches; but of course when water under pressure is admitted, and the skate raised to allow of its resting on a film of water, a considerable portion of the area of the skate is utilised to support the carriage.

The skates are made of cast iron. They consist of a box with a central depression or hole, rounded at its lower part, in which the rounded end of a rod (marked **T** in Fig. 4 and 5) which supports the carriage rests.

The depression which supports the rod descends to within 5 m.m. (about $\frac{1}{5}$ inch) from the surface of the rail, and the bottom of the rod is thus not more than one inch from the rail; the form of the upper part of the depression allows the rod a play of 7 or 8 m.m. (say ⅓ inch) all round. This mode of attachment gives a certain freedom of play between the carriage attachment and the slide, which allows the slide to accommodate itself to inequalities in the road. Hence it is not necessary for the rails to be absolutely on the same horizontal plane in order that the skate should rest on the film of water; and thus M. Barre contends that the rails do not require more attention in maintenance than those of the ordinary railway. The box is closed at the top and open at the bottom, but it has a broad grooved rim all round, which forms the bearing surface which rests on the rail.

(2.) *Method of Supplying Water to the Skate.*—Water is admitted to this box through the aperture marked S, Fig. 4, and is retained by the pressure of the grooved rim upon the rail. The grooves in this bearing surface are arranged as shown in Fig. 6, communication between these grooves being established by passages which are not directly opposite each other. The water which is admitted to the slide through the opening S, as it flows downwards, can only escape by traversing the grooves in the bearing surface; the passages between these grooves are not opposite each other, hence the velocity of the water in its progress along the grooves is decreased, and thus waste of water is checked. When the normal pressure is exerted by the water between the rail and the slide, a film of water from one half to three-quarters of a millimetre in thickness between the surfaces is maintained.

M. Barre states that he made an experiment at Senlis on a skate in the shape of a rectangle 440 mm. long and 220 mm. wide. The weight borne, including the weight of the skate, was 1,060 kg. The pressure in the reservoir maintained by compressed air showed a variation of from 3 to 2 kilog. per c.m., but the pressure measured under the skate remained constant at 1·8 kilog.

M. Barre assumes from this experiment that, as the weight actually borne by the skate was 1,060 kilog., the portion of the total surface of the skates actively employed in supporting this weight was only 558 cm. (about 90 square inches), which corresponds to a rectangle 377 × 157 mm., and that the perimeter of this rectangle multiplied by the depth of the film of water formed the orifice through which the water passed. He states that the escape of water theoretically due to the pressure of 1·8 kilog. through this aperture would have been 15·117 litres per second; but apparently, owing to the resistance to the flow of water occasioned by the grooves, the actual discharge was only 0·967 litres per second. The experiments made on the railway in the Paris Exhibition are stated to have corroborated these earlier experiments.

As regards the weight on the skates in a train, M. Barre assumes his passenger carriages to be light, and to weigh only 3½ tons each; assuming that the average weight of fifty passengers would about equal this weight, and that the loaded vehicle would be borne on six skates, then each skate of the dimensions mentioned would have to support a pressure of about 20 lbs. per square inch over the whole surface, or a pressure of nearly 30 lbs. per square inch over the portion which M. Barre mentions above as being actively employed in supporting the weight.

M. Barre states that he has, moreover, devised an arrangement by which the amount of water consumed by the skates is proportional to the weight upon them; but as this has not yet been completely secured by patent, it cannot be described here.

It is stated that for short runs, up to about a mile, water at a sufficient pressure can be obtained by carrying on the tender reservoirs of water charged under pressure, these reservoirs being re-charged at each station. For longer journeys, M. Barre first proposed to carry a boiler, with engine and pump for compressing the water; in which case the reservoirs would be placed on a tender, and would have to be of considerable capacity, on account of the relatively large amount of water consumed; these reservoirs would be kept filled, whilst the train is in motion, from the waste-water channel in the permanent way, by means of the ordinary water scoop.

M. Barre. however, states that he has now devised a method for supplying the water required for the skates under the several carriages, by passing a part of the water from the hydrants directly into a reservoir placed in each carriage, under the necessary pressure, and in a sufficient quantity to supply the skates for about forty seconds. In this arrangement the turbines under each carriage would have to be shortened to allow space for the water to pass to the reservoir; this plan would therefore be only applicable for long journeys, because in the case of frequent stops and starts the whole force of the water is required for propulsion.

Fig. 1.

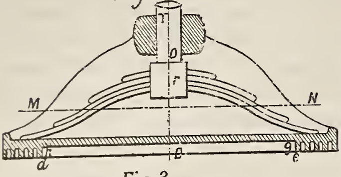


Fig. 2. Section C.D

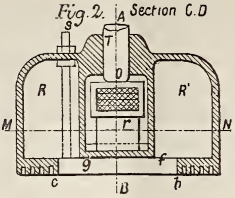


Fig. 4. Section A.B.

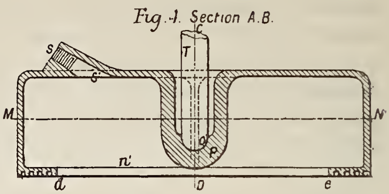


Fig. 3

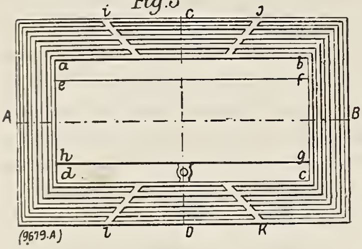


Fig. 5 Section C.D

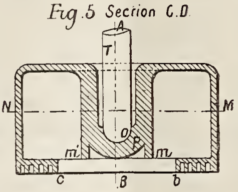


Fig. 6.

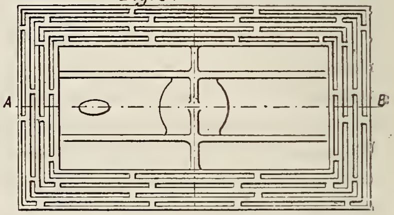


Fig. 7. Section A.B

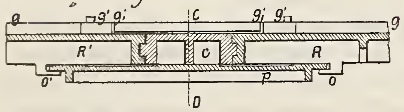


Fig. 8. Section C.D

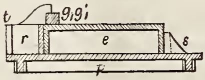


Fig. 10.

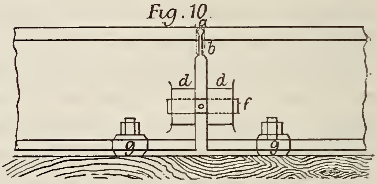


Fig. 9.

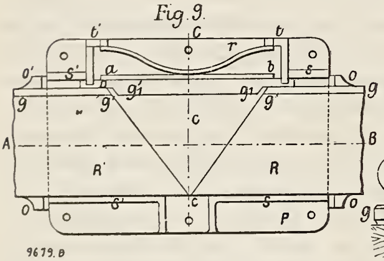


Fig. 11

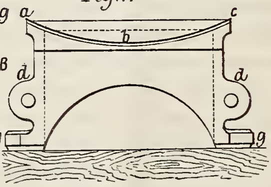


Fig. 12.

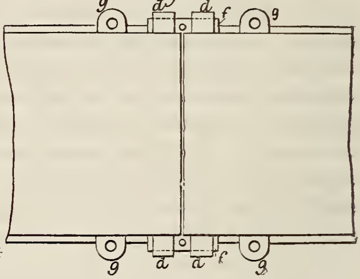


Fig. 15.

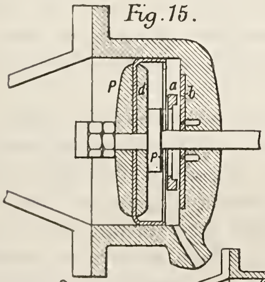


Fig. 16.

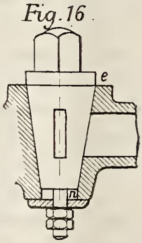


Fig. 17

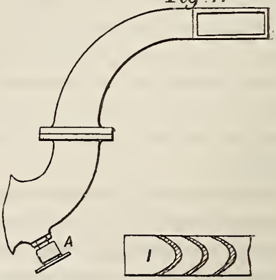


Fig. 13.

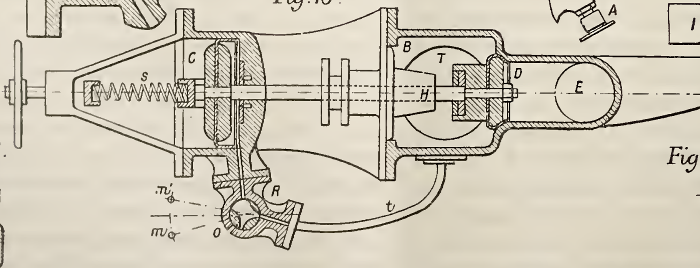


Fig. 14.

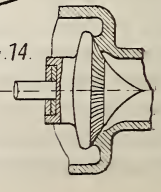


Fig. 18.

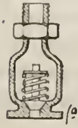


Fig. 19.

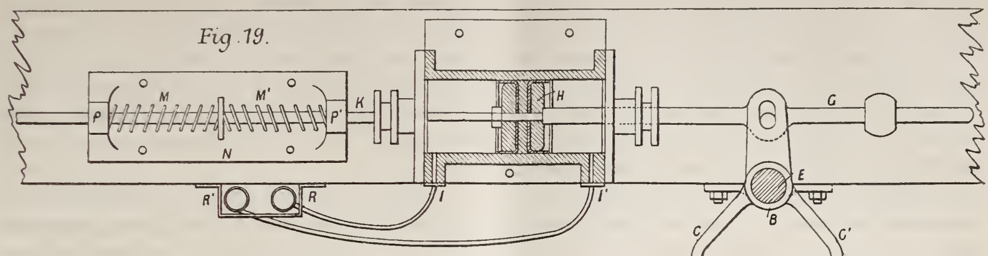


Fig. 20

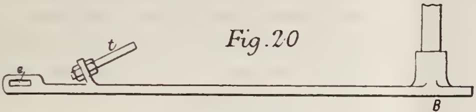


Fig 21

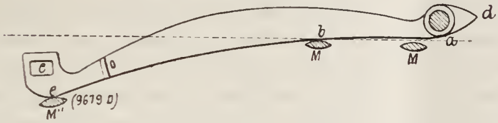


Fig. 22

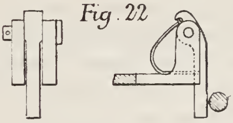


Fig. 23.

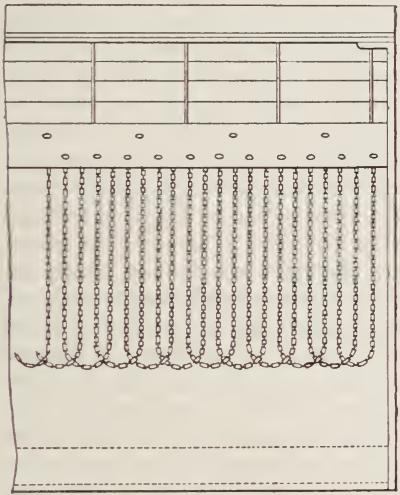
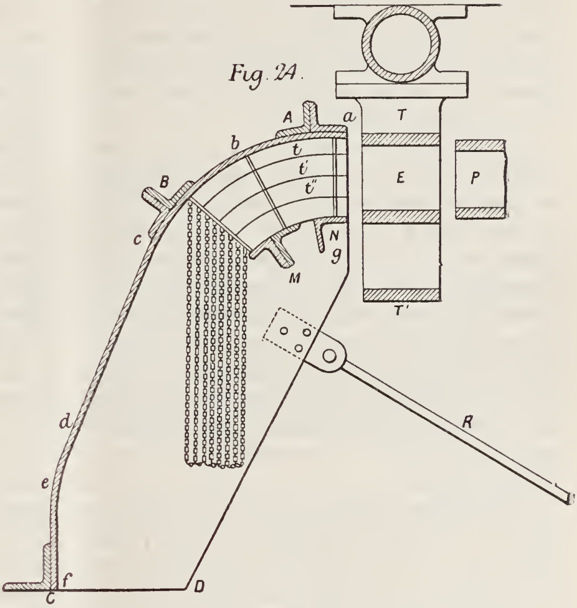

(9679.E)

Fig. 24.



The particulars of this arrangement have not been furnished.

It is to be observed that the expenditure of water for the skates is per second, not per mile, consequently the faster the train goes the less water per mile is consumed.

(3.) *The Rail.*—The rail is of iron; it presents a broad, flat, and perfectly true surface, not liable to be interrupted at any point, and which, at the same time, is free to expand or contract. An extremely ingenious plan for securing this object was proposed by M. Girard, and is shown in Figs. 7, 8, 9. This was, however, found too complicated in practice, and M. Barre has adopted a simpler and equally efficient arrangement.

This method of joining the rails is shown in Figs. 10, 11, 12. A curved groove, *a b c*, is made in the end of each rail, and in this groove is placed a rubber fillet, which has sufficient elasticity to allow for the variations in length of the rail arising from differences of temperature; the rails are secured together by the bolts, *f*, passing through the flanges *d*; *g g* are holding-down bolts, securing the permanent way to the substructure. On the outer side of each rail a guard plate, not shown in the sketch, can be attached, if desired, to serve as a guide for the slides. On curves the superelevation of the outer rail would prevent friction against these guides, as the method of propulsion of the trains would cause all the trains to move at a nearly similar speed, to which the superelevation of the rail would be adapted.

II.—METHODS OF PROPULSION OF THE TRAIN.

(4.) *Arrangements on the Vehicles for Receiving an impulse from the Water of Propulsion.*—Under each carriage is placed a series of vanes arranged longitudinally, as shown in the sketch. (I. Fig. 13). From each series of vanes a pin projects. As the carriage approaches each of the hydrants consecutively this pin opens a cock and allows the water from that hydrant to flow out and act upon the vanes to force forward the carriage; a second pin closes the cock as soon as the series of vanes has passed the hydrant.

(5.) *Hydrants for Propulsion.*—The water which acts on the vanes fixed on the carriages is supplied from a main running the whole length of the line, from which it rises through hydrants (Figs. 13-17) which, as before mentioned, are opened by the mechanism on the train. The main is supplied with water by pumps placed at intervals, and connected with cisterns under pressure; the water used in propelling the train, as well as the water from the skates, falls into a waste-water channel in the permanent way, from which it is returned to the cisterns by the pumps.

The hydrants may be generally described as follows:—They consist of three parts; these parts are a valve chamber, a cylinder, and an automatic controlling valve (Fig. 13).

The water under pressure, which is to be used for propelling the train, flows from the main up the standpipe, T, which is placed in the centre line of the permanent way, and into the valve chamber; in this chamber the valve, D, closes the entrance to the nozzle, E, the pressure of the water at the back of this valve keeping it firmly shut. The valve is opened by means of the spindle attached to it, and which passes through a stuffing-box, H, to a leather-packed piston in the cylinder, C. The diameter of this piston is larger than that of the valve, D. The part of the cylinder, C, which is in front of the piston is in communication with the valve-chamber by means of the pipe, *t*, and the three-way cock, R; one of the openings in this valve, through which the water passes into the cylinder, is much larger than the two others, in order that this passage may not be obstructed.

The water under pressure is delivered to the cylinder, C, in front of the piston, the force exerted being sufficient to drive back the piston and thus to withdraw the valve, D, from its seat: this allows the water to rush from the standpipe and valve-chamber through the nozzle against the row of vanes or pallets, I, beneath the carriage.

The cock, R, is opened by means of levers placed under the tender, and while open it keeps the back valve, D, from its seat and allows the water to escape through the nozzle, E, until the impulse has been completed. A corresponding lever at the other end of the train closes the cock, and stops the jet, until it is opened for a new impulse. It is necessary to have a double set of such levers on the train in order to operate upon the two series of nozzles which are required for driving the train in opposite directions.

The spring, S, assists in throwing back the piston to its normal position when the water is cut off from cylinder, C, and the pipe from the cylinder is then put into communication with the atmosphere through the small opening, O, that serves as a sort of hydraulic brake when the valve, D, returns to its seat.

Fig. 17 illustrates the form of nozzle employed; the valve, A, which is introduced near the bottom, allows the nozzle to be emptied. The arrangement of this valve is shown in Fig. 18, where it will be seen that it is kept open by a spiral spring, except when the water under pressure passes into the nozzle and forces the valve down; but as soon as this pressure is removed, the valve opens and allows the contents of the nozzle to escape.

The distance apart of the hydrants depends on the length of the train. At the Paris Exhibition, the train was a little over 50 feet long, consequently the hydrants had to be placed at intervals of about 48 feet, but if the train had been 130 feet long the hydrants might have been 120 feet apart.

The hydrants at the Paris Exhibition discharged 105 litres (about 22 gallons) per second, under a pressure of 10 kilog. (about 140 lbs. per square inch). This gave a propelling force of 450 kilog. With more powerful apparatus, or a waterfall, 1,000 kilog. of propelling force could be obtained, or the number of hydrants may be multiplied. Thus, with a propelling force of the latter amount, and with four hydrants instead of one, the propelling power would be 4,000 kilog. The water is used over again, and, in fact, it acts only as a lever would.

As regards the speed, a turbine will attain 80 per cent. of the speed attained by the flow of the water, and with a pressure of 10 kilog. per square centimetre, the speed at which the water would pass out of the hydrant would be 44 metres per second.

M. Barre assumes that 80 per cent. of this velocity would be utilised, and that, with that pressure, the train might consequently travel at 120 kilometres, or nearly 70 miles, per hour.

6. *Arrangement for Catching the Water after it has served its purpose of Propulsion.*—An enormous amount of water is projected from the nozzles, which is collected in a suitable channel made in the bed of the permanent way, to be brought back to a pumping station. The spread of the water, after it has acted on the vanes, is checked and directed into the conduit by means of a special arrangement, which is shown in Figs. 23 and 24. P is the mouth of the nozzle, E the line of pallets beneath the carriage, and the structure, A B C D, is a curved apron placed on each side of the pallets and attached to the road bed; as the line of pallets passes between the nozzle of the hydrant and the apron, the water is thrown to the right and left into the collector, the curved plates, t, t^1, t^2 acting to divert it, while its force is further broken by means of the row of chains suspended from the top of the curve as shown in the sketch.

The foregoing are the principal special details of the system, but there are a number of minor devices to overcome obvious difficulties connected with working.

In the event of a train being stopped by a signal, assuming that a nozzle beneath one or more of the carriages has been opened and continues to discharge a jet of water against the pallets beneath the carriage, two operations would be necessary, that of closing the valve immediately to prevent waste of water so long as the train remains standing, and of opening it again when the signal against the train is removed. The arrangement adopted to meet this contingency is shown in Fig. 19. A and A_1 indicate the extreme positions of the valves connected with the nozzles of the line of standpipes. Outside these, and running along the whole length of the train, are two iron tubes, B and B_1, suspended from the arms, C C^1, which are mounted on the shaft E, which also runs along the whole length of the train, suitable couplings in all cases being provided between the carriages. Secured to the central cross-frame under each carriage is the cylinder, H, with its piston-rod, G, connected to the shaft, E, by means of a crank with a slotted hole and pin; openings are made at each end of the cylinder, H, connected by means of the pipes, I and I_1, to other pipes, R R_1 which also extend throughout the train, terminating at the tender. The rod, K, passing through bearings, P P^1, in the bracket, N, carries midway of its length, between the bearings, a disc against which press the spiral springs, M M^1; according to the movement imparted to the piston so is the spring M or M^1 compressed. One end of each of the pipes, R R^1, terminates on the tender in a small receiver, and the whole system is filled with glycerine; the upper part of each receiver is in communication with a small reservoir charged with compressed air, the connection being controlled by means of a tap. The normal position of each of these taps places the receivers in communication with the air; but if either of them is turned, a passage is opened to the compressed air chamber, and the piston, H, is set in movement to the right or left, together with the whole system of the shaft, E, and the rods, B and B^1, which in their movement open or close the valves of the nozzle. By the movement of ths piston, H, the glycerine contained in that part of the system not under pressure is caused to rise in the receiver, and the spring, M or M^1, is compressed. After this operation is performed, if the tap is again turned to its normal position, the piston, H, returns to the middle of the cylinder as soon as the compressed air escapes, the action of the spring and the difference of level of the glycerine in the two receivers being sufficient to overcome the weight of the different parts. This mechanism can be controlled from both ends of the train either to open or close the valves connected with each line of nozzles.

When a train is in motion, the jets upon which it depends for its speed are opened or closed automatically by the special mechanism placed at each end of the train, as already explained; four of these devices are, therefore, necessary, two for controlling the series of nozzles which propel the train in one direction, and the other two for actuating those which send the train in the opposite direction. The diagrams, Figs. 20 to 22, give an idea of the arrangement adopted for this purpose; the arm that operates the valve of the nozzle has a parabolic working face, against which the lever of the valve comes in contact, the movement of the train causing the arm to pass over it gradually, without any shock, and forcing the valve lever to take the necessary position. The corresponding arm at the end of the train is arranged so as to give a reverse movement, bringing the lever of the valve back to its original position, and thus shutting off the jet of water. This brief description will, it is hoped, enable the general arrangements of the system to be understood.

Between the 12th July, 1889, and the 6th November, that is in 114 days, there were carried 118,000 passengers on the short line at the Exhibition. The total length traversed by the train was 1,200 kilometres, or 750 miles. The propellers were opened 4,000 times and closed 4,000 times, and they acted as well on the last day as they did on the first day. At the end of the time the automatic valves did not exhibit the slightest wear or difficulty of working. The rails and the skates were equally free from any appearance of wear; in fact no repairs of any kind were needed from the opening till the closing of the line.

It is necessary now to consider the question of working. In the first place the character of the train differs essentially from that on an ordinary railway. The first-class carriages, each containing 50 passengers, are proposed to weigh from 3,000 to 3,500 kilog., say, three to four tons, that is to say, about 160 pounds per passenger. The ordinary railway carriage may be said to weigh anything from 300 pounds per passenger upwards.

This great reduction of weight is, it is supposed, made on the assumption that the shocks to the vehicles on such a railway will be very slight compared with those on a railway whose carriages are connected with spring buffers and draw-bars, and propelled by locomotive engines, for in an ordinary train the locomotive engine with its tender not only contributes a very considerable amount of dead weight, but being attached to the train, its action upon the vehicles in propelling the train and in rapid stops occasionally cause shocks; these shocks are indeed almost necessarily incidental to propulsion by means of a locomotive engine, and render it imperative to provide much strength and consequent weight in the carriages.

The heaviest vehicle on the sliding railway is the one employed to carry both the conductor and the water for the skates, the weight of which is not assumed to exceed 8,000 kilog., say 8 tons.

Then again M. Barre proposes to take steps to reduce the resistance from the air at high speeds. This resistance acts in an ordinary train not only on the front of the train, but against the front of each vehicle in a train. dependent upon the intervals between the vehicles.

M. Barre proposes to make the train continuous, in the shape of the half of a cigar divided longitudinally, articulated so as to allow of its passing round curves, and with pointed ends, and he urges that side winds would have less effect on this train than on an ordinary train, in consequence of the less height it would stand above the rails, and of the curved top. Moreover, it is argued that the resistance arising from the flanges of the wheels being pressed against the rails in a strong side wind would not be so great a cause of retardation in M. Barre's as in an ordinary railway.

The following calculations as to the working have been supplied by M. Barre, and must be taken on his responsibility, as I have had no opportunity of verifying or checking them. In stating them it will therefore be more convenient to retain the metric numeration.

The work of compression required to maintain a film of water between the bearer or skate and the rail during the progress of the train, as compared with the economy resulting from the diminished resistance due to the sliding motion, is given by M. Barre as follows:—Assume a train of four carriages, each containing 50 passengers, or 200 passengers in all. With the sliding system on a short railway the train would have a tender carrying the necessary supply of water, and the weight of the train would be made up as follows:—

	Tons.
4 carriages, dead weight, 3½ tons each	14
200 passengers, say	14
2 tenders, 6 tons each	12
	40

Assume the train of 6 vehicles to be supported on 36 bearers or skates of 22 cm. × 44 cm. Now according to the experiments made on the line at the French Exhibition, each of these would require nearly 1 litre (or 1·76 pints) of water per second as a maximum. Thus the total consumption of water in the train for this purpose would be 36 litres (or 7·92 gallons per second.

These 36 litres might, in the case of frequent stoppages, be taken in from the principal water-main, which is maintained at a pressure of 10 kilogrammes per square centimetre, or 144 lbs. per square inch, which is equivalent to a column of water of 100 metres in height.

This pressure is far in excess of the pressure actually necessary to produce a film of water sufficient to carry the skates. But upon this supposition the work absorbed per second to maintain the sliding of the train would thus be—36 kilogrametres × 100 metres = 3,600 kilogrametres or 48 horse-power.

If the train, which weighs 40 tons, slides at the rate of 20 metres per second—that is 72 kilometres, or nearly 45 miles per hour—the resistance to the sliding, as gathered from the experiments which have been made on the model railway at the Exhibition, is 1 kilog. (= 2·2 lbs.) per ton as a maximum; so that the total resistance of the train would be 40 kilog., which, multiplied by 20 metres per second, gives 800 kilogrametres, or 10·66 horse-power. Hence the work to be done in sliding and traction, or propulsion, would be 48 + 10·66 horse-power, or 56·66 horse-power.

The work done in the propulsion of the train would be effected by the water which flowed through the nozzles; and this water, during its action on the train, would not be confined as if it were driving a piston, but it would be acting in the open air, consequently more water would be required to produce the work on the train than the amount which theory would show to be sufficient to effect the work, if acting under a given head in a confined space.

From the conditions of the working at the Paris Exhibition, it may have been difficult to ascertain the actual quantity of water used in proportion to the work done in propelling the train.

M. Barre states that his observations show that from 75 per cent. to 50 per cent. of the water is utilised by the turbine under the carriages; and on the other hand he contends that the consumption of fuel in the locomotive of any ordinary railway would be nearly double that which would be necessary for the proposed fixed pumping engines, because of the regularity of working of these latter; and that as the water is not wasted but is pumped back, and only coal is consumed, it is fair for purposes of comparison only to take into account the horse-power shown to be required by calculation.

Assuming, however, that 50 per cent. of the water only is utilised, and that the quantity of water incidental to the propulsion would be double the amount theoretically required, this would bring up the combined horse-power for sliding and for traction to at least 70 horse-power.

To compare this with an ordinary railway, we will assume a train composed of corresponding elements, but in which the carriages would necessarily be heavier, viz.:—

	Tons.
4 carriages weighing 6,500 kils., or say	26
200 passengers averaging 70 kils. each, say	14
1 locomotive with tender, say	40
Total........	80

This weight of 40 tons for the locomotive and tender is not excessive, if a speed of 45 miles per hour is to be assumed on a railway similar to the one under consideration, with many stops, because a powerful engine is required for rapidity in starting and stopping.

The resistances to this train are assumed by M. Barre as follows:—

	Kils.
For the locomotive at 8 kils. per ton	320
,, ,, carriages at 4 kil. = 8 lbs...	160
	480

Upon this calculation the work to be done in propelling the train on an ordinary railway would be 480 kil. × 20_m = 9,600 kil. = 128 horse-power.

Thus, even in the unfavourable case of the sliding railway being worked with frequent stops, and taking the water for supplying the skates from the principal water main at considerably more than double the pressure actually required, there would be a considerable economy in the traction on this system, as the tractive force to be exerted in moving the sliding train would only be between one-half and two-thirds of that upon an ordinary railway with wheeled carriages and a locomotive.

The exact arrangements under which the trains are to be run on the line at Neasden have not yet been made public, but M. Barre gives the following general calculations, which show similarly the economy in working which would result from the adoption of the system upon a larger scale.

He assumes a train composed of 20 carriages, each carried on six skates, and a tender supported on 12 skates, which would carry a steam pump for providing the necessary pressure for the water for the skates This water would be taken up by an ordinary water scoop from the channel in the centre of the line, which receives the water discharged by the hydrants in propelling the train. It would therefore be at the atmospheric pressure, and it would require to be compressed by the engine and pumps on the tender; but 2½ kilog. per c.m., equivalent to about 35 pounds to the square inch of compression, would suffice in this case, because, according to experiments made by a pressure gauge on skates of similar dimension, it was found that 1·8 kilog. under the skates (which is equivalent to between 25 pounds and 26 pounds per square inch) was sufficient to support them on a film of water. The compression to 2½ kilog. would represent a column of water of 25 metres in height.

The number of skates in the train would be 132, and the water required for their supply would thus be 132 litres per second.

M. Barre proposes to put pressure on this water by means of a pump running at a very high velocity, and therefore of a relatively small weight. The work done for the compression would be 132 kilog. × 25 metres = 3,300 kilogrametres, or 44 horse-power. The total weight of the train would be made up as follows:—

	Tons.
20 carriages, weighing each 3,500 kilog...	70
1,000 passengers, at an average of 70 kilog.	70
1 tender, weighing	12
Total	152

If we assume the train to travel as before, at 20 metres per second (equivalent to 45 miles per hour), and if we assume the resistance of the slides to be that shown by the experiments, viz., 1 kilog. per ton, the work done in propulsion will be 152 kilog. × 20^m = 3,040 kilog., or somewhat over 40 horse-power.

Hence the work done in sliding and propulsion of these trains running long distances will be 44 + 40 = 84 horse-power on the level; and assuming, as before, that the water which was ejected from the nozzle during the passage of the train was double that actually required for doing the work, if applied in a confined space, the sliding train would absorb, say, 124 horse-power.

A train conveying a similar number of passengers, on wheels, and drawn by a locomotive, would be made up as follows:—

	Tons.	
20 carriages with dead weight of 6½ tons	= 130	
1,000 passengers at the average of 70 kilog. each	= 70	
		— 200
1 locomotive....................	45	
1 tender........................	15	
		— 60
		260

The resistance of the train may be considered to be as follows, viz., 4 kilogrammes for the carriages, and double that for the engine and tender. Thus:—

	Kilog.
The carriages and the passengers, weighing 200 tons, at 4 kilogrammes per ton	= 800
The locomotive and tender weighing 60 tons, at, say, 8 kilogrammes per ton	= 480
Total....	1,280

Assuming the same speed as before, viz., 20 metres per second, or 45 miles per hour, 1,280 kilog. × 20 metres = 25,600 kilogrametres, or 340 horse-power. Thus the tractive power required to draw the train on a long distance railway would be considerably less than one-half of that required for a train on wheels, with a locomotive.

Of course, the effect of inclines would be favourable to the sliding railway, in that the dead weight of the train in proportion to the effective load of passengers would be smaller. But, of course, the hydrants would have to be placed at nearer intervals in proportion to the steepness of the incline.

It is further alleged that there would, moreover, be economy in wear and tear of carriages and waggons, arising from the absence of shocks and vibration which occur on ordinary railways, as well as the further saving in maintenance, arising from the absence of greasing axle-boxes, &c.

We will now consider the general conditions of working of the two systems. The sliding railway may be placed in the category of a rope railway, propelled by water instead of by a rope. In each case the locomotive of the ordinary railway is replaced by motive power supplied at fixed intervals along the line.

The advantage of the water propulsion is that it is applied at each point at the moment, and in the amount which is wanted; and although the first installation would have to be adapted to the maximum traffic to be expected, the consumption of water would strictly correspond with the actual weight of traffic; whereas the whole weight of the rope has to be set in motion, and the rope continues to move along the whole length of the section during the passage of each train.

There remains the important point of capital expenditure for establishing the line; that is to say, the cost of the installation of the water main and pumping appliances, the hydrants for propelling the train, the appliances for catching the waste water, and the conduit for conveying it back to the various pumping stations.

Upon these points I have at present no information, and so much depends upon the proportionate sizes of the several parts, that it would not be advisable to submit merely assumed figures; but the comparative lightness of the rolling stock would allow of a considerably reduced expenditure over that of ordinary railways in some of the principal branches of construction.

The experimental railway which M. Barre proposes to erect at Neasden will, it is expected, furnish many necessary details upon these and other points which have not yet been fully explained.

I will now recapitulate the points which M. Barre claims to be the advantages of the system:—

1. Smoothness of motion—that is to say, absolute freedom from vibration or jarring—and absence of dust.

2. Absence of noise and smoke.

3. Small risk of running off the line, because no object, however small, can pass under the skates.

4. Power of stopping almost instantaneously, very smoothly, and without any shocks; diminished chances of collision from meeting trains; power of stopping on a gradient as steep as 45 in 100.

5. Ease in ascending inclines, and in traversing curves with a radius as small as 2 chains.

6. Power of attaining a speed of 100 miles per hour on the level if the pressure in the water main be increased to a little over 300 lbs. to the square inch.

7. Remarkable lightness of the carriages and waggons, which would not weigh above one-half those on ordinary railways; absence of heavy locomotives and tenders; and consequent lightness of bridges and other works of construction.

8. Almost entire saving in cost of traction in mountainous countries in which there are large water falls, and very large saving in cost of traction even where all the water has to be pumped.

9. Economy in train expenses, resulting from the abolition of greasing, and from the saving of repairs of wheels, axles, grease boxes, brake apparatus.

10. Large saving on the maintenance of the steam-engines; firstly, because there would be less horse-power required to do a given work; and, secondly, because the fixed engines which pump the water would be worked under conditions more favourable for economy than is possible with locomotive engines.

M. Barre gives the following as some of the instances in which the sliding railway could be usefully applied.

1. In mountainous countries where there are large waterfalls, which would supply the water, and in which the inclines are greater than ordinary railways can surmount.

2. On cable railways, especially those with steep inclines, where the use of wheels sometimes causes serious accidents, the cable traction might be continued, the water-skate alone being employed. If the cable broke, all that would be necessary would be to stop the flow of water into the skate, and the vehicles would come to rest on inclines as great as 45 in 100.

3. For moving heavy weights of large bulk. In this case a mechanical traction by means of rack and pinion work could be resorted to, the sliding arrangement alone being adopted.

The use of springs for equalising the weight on the several supports would be replaced by hydraulic cylinders, in which the rod which supports the weight on the skates would become the piston. The cylinders would carry the framework and be associated into groups; the cylinders in each group being in communication, but each group being independent of the other groups. Under these arrangements any slight difference in the levels of the rails would be compensated.

For moving large guns placed in cupolas for coast defence, the sliding system would afford peculiar advantages, as well as for the transport across an isthmus of large vessels floating in caissons. For this latter application of the system, it may be mentioned that an iron caisson 600 ft. long and 60 ft. wide, affording 26 ft. draught of water, would weigh about 44,000 tons in complete working order, it would suffice for supporting this to have 432 skates, each one metre wide by two metres long, supplied with a water pressure of about 70 lbs. per square inch; and it would require 8,000 horse-power to propel this at the rate of a little over two miles per hour on an incline of 1 in 143.

4. In metropolitan railways, where the traffic is continuous, small trains holding, say, 100 seats each, could follow each other at rapid intervals. If these railways are underground, the system would afford the special advantages of absence of smoke, noise, and dust, as well as smoothness of motion, and great speed between stations situated at short distances apart.

For overhead railways, the facility of passing round curves, and on steep gradients, as well as the absence of smoke and noise, would be specially advantageous, whilst the viaducts might be of very light construction, compared with those required to be used by locomotives. The columns supporting the line would form accumulators for the water under pressure, and all the parts could be carefully protected from frost.

5. M. Barre states, in conclusion, that the sliding railway seems to be especially suited to the Channel Tunnel, in which the train might, on arriving at one end, be passed on to a truck on skates, and conveyed through the tunnel in a quarter of an hour, and if the line were extended on both sides of the Channel, to London and to Paris, the time of transit between the two cities need not exceed two hours.

It may be assumed that, given a very high pressure to the water of propulsion, very great speed might be obtained on this railway with absolute smoothness of motion and freedom from dust, which would constitute the perfection of travelling, and would undoubtedly be a most luxurious mode of progression. But in the absence of sufficient experimental data upon which the actual quantities of water required for propelling the train could be safely based, it is quite impossible to argue how far such a system might be made applicable to general conditions of traffic. This question will, however, receive an early solution.

In the first place, the company of the *Chemins de fer Glissants perfectionnés* proposes to fit up a line of a short length, with complete apparatus, in England, in the course of the present year, and Sir Edward Watkin has placed a site at their disposal at Neasden.

In addition to this, the company have applied, under date of the 7th February last, to the municipality of Paris for permission to construct an elevated metropolitan railway in Paris, between the Place Clichy and La Villette. The line is intended to follow exactly the curves and gradients of the central footway in the Boulevards between these two points. It would be carried upon an elegant trellis work, of which the supporting columns would be light, and would in no way impede the traffic. Hydrants would be placed on each side, at distances apart of forty metres, the water supply being under a pressure of about 140 lbs. per square inch.

It is proposed to run trains containing 100 passengers each at intervals of one or two minutes, which would admit of 12,000 passengers per hour being carried in the two directions.

There would be three intermediate stations between the Place Clichy and La Villette, one at the Place Pigalle, another at the Boulevard Ornano, and the third at La Chapelle. The distance, somewhat over four miles, between the Place Clichy and La Villette, including the stoppages at the three intermediate stations, is intended to be traversed in seven minutes. The charge for the whole or any part of the distance would be 10 centimes for second-class, and 20 centimes for first-class. The floor of the carriages would be on a level with the platforms, and the carriages would be lighted by electric light, and would be warmed in winter.

In addition to staircases for ascending and descending, each station would be provided with hydraulic lifts, to be worked continuously, for raising passengers from the street level to the railway platform, where a train would always be ready to start.

In conclusion, I may mention that the model of the sliding railway, which was erected and worked at the Paris Exhibition, is about to be transferred to the Exhibition at Edinburgh, where it will be run continuously, as it was in Paris.

DISCUSSION.

The CHAIRMAN said anyone did good service who brought before the Society, even without implicit faith in it, anything which was novel, interesting, and ingenious. As to whether any particular apparatus would or would not prove successful, it was better not to indulge in prophecy. Not many years ago, anyone who had said that you would within a few years be able to hear a person talk who was 100 miles away from you, and this by means of electricity, would have been laughed at, and he was old enough to know that one should not look upon anything (except that $2 + 2 = 5$) with absolute disbelief. This matter divided itself into two main heads—the skate and supports and the mode of propulsion. The supports might be used, independently of the mode of propulsion, as adjuncts to moving a train by a rope, or by electricity, or even possibly by a locomotive on another set of rails; but he did not think anyone would suggest the possibility of a hydraulic propulsion unless the vehicles were carried on similar supports. M. Barre said the friction was as little as 1-2,000th of the incident load, and he estimated 1-1,000th, or 1 kil. per ton, as the resistance to traction on the skates. He would accept what was put down, 4 kil. or about 7 pounds per ton, as the resistance of railway carriages for low speeds on the level with a good road, but it was wrong to double that for a locomotive. Nevertheless, he did not imagine for one moment that anyone would attempt to propel by water-jets a train having the resistance due to being carried on wheels with axles and axle-boxes. He could not agree with M. Barre that this mode of propulsion obviously lent itself to steep inclines, because of the small weight of the trains. The more you diminished the resistance of the rail on the level the more important did any deviation from the level become. If you had a bad road on which a horse exerting a force of 40 lbs. to the ton, could just draw the load along, if you came to a slight incline, it only added say 1 lb. to the load, and the horse had to exert 41 lbs. of force instead of 40. But if by this *chemin de fer glissant* you had a resistance as low as 1-1,000th, obviously if you had an incline, you doubled the resistance at once. Thus, pardoxical as it might seem, the more the resistance was diminished the more important, relatively, became the incline, though of course the positive advantage due to the lighter vehicles would remain. M. Barre evidently felt the difficulty with regard to the wind resistance, which at high speed was very great indeed, by suggesting that the train should be made in a half-cigar shape. When he was an apprentice, he helped to make a locomotive for Lord Dundonald to run on the Greenwich line, in which the same idea was embodied, the front being made like the bow of a ship to cut the air. With regard to the particular mode of getting rid of friction by water-borne skates, every mechanical draughtsman who had ever happened to let one large drawing-board fall down flat on another knew how beautifully one rested on the other, with a film of air between, and, in fact, floated on that fluid film. When he was in the United States in 1853 there was a steamboat which the boatmen used to call the smoothing-iron, which ran from Jersey city to New York. The inventor had come to the conclusion, quite rightly, that the principal resistance to the passage of a vessel through the water was the skin resistance, and he built a boat with a very flat bottom, below which he put about six small kelsons, so as to divide the bottom into five compartments running longitudinally; the forward ends were closed, but at the after end they were open but covered with a projecting board at the back to keep the foam from splashing about, and it was this which gave the boat its nickname. Close to the front end of the cavities formed by these kelsons and the boat's bottom between them, compressed air was introduced from an air pump worked by the engine, the idea being to have only the friction between water and air instead of between the water and the hull. That boat worked for several years, and he was told there was no doubt that the introduction of air did diminish the resistance, nearly to the extent of the power required to work the air pump. For many years past, for certain purposes, some engineers had given up packing pump pistons; they were made to fit fairly well, and a number of grooves were turned in the edge, into which the water got, and before it could get out again the piston had reversed its direction of motion and was going the other way, and by these simple means of using plain grooves you got a fairly tight piston without any packing at all. M. Barre seemed to have done much the same with the underside of his skates, the grooves in which looked like a design for the labyrinth at Hampton Court. When the water got in it did not know how to get out again. He understood M. Barre to say that according to his view something like $1\frac{1}{2}$in. of the margin was not operative for the purpose of support, but that for that margin there was simply the passage of the water, and that he calculated his expenditure of water from the girth within the skate, less the $1\frac{1}{2}$ inch, and from the elevation which was something like $\frac{1}{32}$ inch; and that the labyrinth appeared to work very well, the discharge of water being only about one-ninth of what it would be otherwise. But there was something, not very much, which had not been taken into account, which added to the weight, and that was the pressure exerted, when water issued from between two discs, to bring these two discs together. That was the reason why safety-valves played ugly tricks sometimes. He remembered, again, in the days of his apprenticeship, being taken to a sugar refinery, where there was a process in use of blowing air through the sugar for certain purposes, the air being blown in by a pair of bellows, which had a safety-valve at the top, loaded with a weight. The bellows burst, and it was thought the weight was too great, so it was taken off, and even then it was found that the valve was held down, and required a very great force to lift it. If you took a round piece of card, say three-inch diameter, and another of the same size, and put a quill through the top one and blew down it, and then removed the support from the under one, if it were perfectly level it would stick up against the upper one. There would be the same effect with this water, and in that way there would be a certain addition to the weight of these skates, due to the atmospheric pressure brought on them by the delivery of the water. It appeared from M. Barre's experiments, with varying loads and varying pressures, that the expenditure of water varied very nearly with the square root of the pressure, and it would appear, therefore, as if it would be economical to increase the pressure, and to increase the load. Taking the calculations made for the hypothetical train, it appeared that 44 theoretical horse-power were required to uphold the train on the skates, and 40 horse-power for propulsion, but the 40 was only theoretical, and M. Barre proposed to double it, making 124 in all. He doubted very much the economy of fuel which it was suggested would be obtained from using stationary engines. A better result might be obtained from some stationary condensing-engines than was ever obtained by a locomotive which did not condense; but, as a rule very few stationary engines, non-condensing, worked so economically as the locomotives on a well-managed railway. He had been trying to see what the expenditure of water came to, and found it was about 23,200 gallons per mile, running at 45 miles an hour—here came in the paradox that by this method slow travelling would be more expensive than fast—which, at 23·2 gallons per head would be enough for 100 persons for a day. The London and North-Western Railway engines ran round the world every four hours; they girdled the earth six times in the twenty-four hours, and with this consumption as much water would be required under these skates as would supply three Londons, which seemed a large quantity of fluid to deal with. Of course it was to be collected and purified over again; but still it looked formidable. He was glad the matter was to be tried on a line about a mile long, and in the open, and they would then be in a better position to judge of the practical results of this very beautiful invention. He hoped when the experiment had been fairly made, Sir Douglas Galton would come there again and state the results.

Mr. HARRINGTON asked what was to be done in the case of a severe frost.

Mr. SYME asked what were the arrangements for stopping or braking a train. The expenditure of water would no doubt be very heavy—in Paris they used about two tons a minute—and the leakage appeared to be rather large. He should also like to know the speed attained on the various experimental railways. It did not appear to be anything like 70 miles an hour in Paris.

The CHAIRMAN said 8 metres a second was said to have been done in Paris, but with a length of only 170 metres, and a train 50 feet long, it was obvious there was not much opportunity of getting up speed.

Mr. BLAKESLEY said he had heard that it was proposed to mix glycerine with the water to prevent freezing, but a very large quantity would be required in the case of a severe frost, and it might interfere with the other properties of the water.

Mr. LASCELLES SCOTT said the late Mr. Brunel took a great interest in the researches of M. Girard on this question, and at his request he made several experiments with regard to the viscosity of different fluids, with the object of ascertaining how water could best be preserved from the effects of frost. Glycerine was given up as being less suitable than chloride of calcium or a neutral solution of chloride of zinc, either of which would be cheaper and more efficacious.

Mr. MONTEFIORE said M. Barre had made various experiments on this matter, but they had not been carried very far, and there had not been many days of severe frost this winter. Amongst other things, chloride of magnesium had been tried, which was very cheap, and might, perhaps, be better than the substances just mentioned, but the question had not yet been solved whether salts of that nature might not exercise a chemical action on the metal; which glycerine would not, though it would be more expensive. M. Barre thought the water might be kept sufficiently warm by the steam from the engines, in countries like France or England, where the frost was not very severe. Of course, that plan would not do in Russia. The grooves on the under sides of the skates did not form a labyrinth; they had no connection with one another, and the water could only escape by passing between the surface and the rail. A train at any speed would soon be brought up by stopping the supply of water to the skates, which would then act as a continuous brake. For starting it would probably be found convenient for all the stations to be on a slight incline; this would make it easier to pull up, and would also give an advantage in starting again down the next incline. That was how it was arranged in Paris. The train started by its own weight as soon as water was admitted under the skates, and it was only after a few seconds that the water propellers were opened. The train would have to be started by water propulsion only, but the objection to that would be the suddenness of the start, which would send the train on with a jerk.

Mr. LASCELLES SCOTT remarked that chloride of magnesium, being very liable to decomposition, was condemned by Mr. Brunel. The other salts he had mentioned were quite innocuous.

Mr. SMARTT asked if there would not be danger of collision in frosty weather from ice being formed on the rails along which the train would continue to slide, even if the water were turned off.

The CHAIRMAN said there was one point he had forgotten to mention with regard to the saving in lateral resistance which M. Barre took credit for. The skates had each four projections at the corners, which came down on each side of the rail to keep the train on the line. These had no rolling motion like the flange of a wheel, and as there could be no film between them and the side of the rail, he could not see why the side friction would not be as great as on an ordinary railway, if not greater.

Sir **Douglas Galton**, in reply, said M. Barre proposed to use the water of condensation from the fixed engines for warming the water in winter, which was supplied to the skates; he did not depend on the use of glycerine or any other substance. Of course he assumed throughout that the frosts in France and countries where it would be most applicable, would not be very severe. If he went into a mountainous country like Switzerland and used the waterfalls, the railway would be liable to be stopped for a great part of the winter. If the water froze on the rail, he considered the film of ice would be so thin that it would be forced off by the passing of the train. With regard to the Chairman's last question about the side friction, he confessed he did not see the answer to it, and perhaps M. Barre had taken more credit for diminution of side friction than he was entitled to; but he thought what he meant to convey was that the resistance in going round curves would be less from the fact that the train supports would all be travelling at equal speeds, the superelevation of the outer rail being calculated for that purpose, and so preventing that friction of the flange which took place very often in ordinary railways. Mr. Montefiore had answered most of the questions, and better than [he could, because, as a director of the Company, he was connected with M. Barre in Paris, and so had more knowledge of the matter.

The **Chairman** then proposed a vote of thanks to Sir Douglas Galton, which was carried unanimously.

Miscellaneous.

SOAP IN INDIA.

There is an ample demand for the increased use of soap in India, for at present, after allowing for local manufacture, it may be said of the people of India that soap is to them an unknown luxury, the consumption being at the rate of less than a shilling's worth for every hundred inhabitants a year.

The imports of soap have, it is true, more than doubled during the last six years, and the trade is steadily increasing from year to year. It is not anything like a large trade even now, for the largest quantity yet imported, that of the year ending April, 1889, reached only 74,000 cwt., the value of which was £102,289. The bulk of this was from England, the other European States supplying only a little over 3,000 cwt. The soap factories at Bombay, Jeypore, and Meerut are doing well and increasing their out-turn, and the local demand will most probably now go on increasing from year to year.

The soap manufactured by these companies is much liked by the natives, and particularly that variety called "vegetable" soap is in much request. Hindus of the orthodox type would not touch a soap made of tallow or animal fat, as it is against the principles of their religion to do so. Such men and women in general, therefore, did not use soap at all, and contented themselves by cleaning their hands with simple earth, or the soap-nuts of species of *sapindus* and the legumes of *Acacia concinna*. Since the production of the vegetable soap the objection to the introduction of that article in the native Hindu household is overcome, and soap is beginning to replace the primitive clay and vegetable substances used. About 8,000 cwt. of native-made soap is now exported annually.

The imports of soap of all kinds into British India have been as follows in the last six years:—

	Cwt.
1883-84	34,447
1884-85	38,075
1885-86	49,804
1886-87	59,016
1887-88	61,139
1888-89	74,072

The imports since this have, however, been declining. Of 500,000 cwt. of British soap which we exported in 1888, 75,275 cwt. went to India.

RAILWAY DEVELOPMENT IN ALGERIA.

Consul-General Playfair in his last report says that no new concession of railways was made during 1888, but several new lines have been opened of no small interest, if not to British commerce, at least to that large section of the community which annually migrates to the Mediterranean in search of health, pleasure, or to avoid the vigour of the English climate in winter. In the department of Algiers the line to Tiziouzon has been completed, so that Fort National, the capital, as it were, of Kabylia, is easily reached in one day from Algiers. The last remaining section, that from d'Haussonvilliers to Tiziozon, about 25 kilometres in length, was opened on May 28, 1888. In Constantine two important lines have been completed. The first is that to Biskra, of which the last section, from El-Kantara to Biskra, 56 kilometres in length, was opened on July 1, 1888. The traveller can now reach this place from the sea of Philippeville in one day, and from Constantine in ten hours. It is believed that this will soon become one of the most important health resorts in the Mediterranean. Its climate during the winter months is warm, uniform, and almost rainless; a large hotel has been built, and Consul Playfair says that for people who are content to sacrifice everything for the sake of climate it has no rival on this side of Egypt. During the summer months it is one of the hottest places on the earth's surface, owing to its situation at the foot of the Awies Mountains, which shelter it from the cold winds of the north, while it is exposed to the hot winds which pass over the great expanse of desert lying to the south. At this season the mean temperature is 18° Fahrenheit hotter than that of Algiers, whereas in winter the difference is not very sensible. At all seasons, but especially in summer, heat sets in immediately after sunrise, but when the sun has set it becomes as rapidly cool. The absolute maximum of the thermometer may be stated at 136°, and the minimum 17° Fahrenheit. The maximum temperature each day is reached at about 3 p.m., and each year at about July 25. The traveller going to or coming from Biskra must pass through Batna about half way between it and Constantine. This is a centre whence numerous excursions may be made; one is of considerable interest, the ancient Roman city of Thamugas (modern Timegoad) has now been entirely unearthed, and is almost as remarkable as Pompeii. The second line in the department of Constantine, just opened, is from the station of Souk-Abtas, the country of St. Augustine, southwards to Tebessa, where there are many very fine Roman ruins. Previously this had to be reached by long and fatiguing routes. It can now be reached with ease in seven hours from the main line running between Algiers and Tunis. A fourth line has been opened in the department of Oran from Mostaganem on the sea coast to Tiaret, thus rendering easily accessible a country which hitherto no traveller could reach without great difficulty and fatigue.

Correspondence.

OCEAN PENNY POSTAGE.

I read with much interest the discussion at the Society of Arts upon what is called "Ocean Penny Postage." With Mr. Heaton's object in reducing ocean postage as far as practicable every one must sympathise; but does any one really believe that the rate can be reduced so low as 1d.? Does Mr. Heaton himself believe it? I must say that, after reading his admissions in the discussion on his paper before the Royal Colonial Institute, I feel grave doubts whether he really means what he says, or whether he does not know better, and is not, therefore, deceiving those who do not. Some sort of service might perhaps be got for 1d., but he leads people to suppose that under his scheme the same excellent service would be afforded which is given under the existing arrangements. Of course this is impracticable, and I think Mr. Heaton should explain more clearly what sort of service he thinks could be given for 1d. Would merchants, &c., be satisfied with it? Or, in addition to the 1d. ocean service, should we have to keep up the 5d. service as well? Would it not be wiser to abandon what is perhaps merely an *ignis fatuus*, at any rate under present circumstances, and to aim at a more practicable and reasonable proposal, viz., that of retaining, with such reduction of cost as may be possible, the present high-rate express service to India, Australia, &c., and of establishing in addition to it an alternative cheap post, by which, for a postage of (say) 2d., letters could be sent as cargo by steamers to all parts of the British Empire? This, or something like it, is the arrangement suggested, I believe, by the Imperial Federation League. This would surely meet all reasonable requirements as regards keeping up home ties, &c.; and, in so far as it would place no appreciable additional burden on the revenue, nor require any special organisation for working it, could be adopted to-morrow.

LOWTHER BRIDGER.

11, Sumner-place,
South Kensington, S.W.
March 5, 1890.

Obituary.

SIR EDWARD BAINES.—Sir Edward Baines, a member of the Society of Arts since 1856, died at his residence, St. Ann's-hill, Burley, Leeds, on Sunday, 2nd inst., in his 90th year. He was born at Leeds May 28, 1800, and began the active work of life at the age of 15. He was engaged upon the staff of the *Leeds Mercury*, of which he subsequently became editor and senior proprietor. In his 18th year he advocated the formation of a literary and philosophical society for Leeds, and from 1837 to 1887 he was president of the Yorkshire Union of Mechanics Institutes. On the death of his brother, the Right Hon. M. T. Baines, in 1859, he was elected member of Parliament for Leeds, and he held that seat until 1874. Sir Edward Baines joined in discussions at the meetings of the Society, and communications from him on Mechanics' Institutes and the Yorkshire Union were printed in this *Journal*.

General Notes.

THE ARGENTINE REPUBLIC. — Mr. H. D. Hoskold, a member of the Society, and the Director of the National Department of Mines and Geology of the Argentine Republic, has sent to the Secretary a number of copies of his Report on the Mines, Metallurgy, Mining Laws, &c., of the Argentine Republic, for distribution among members of the Society of Arts. Any member desiring a copy can obtain one by personal application, or on sending the cost of postage, 9d., to the Secretary. The Report is royal octavo, of 600 pages, and is illustrated by maps, plans, &c. It is written in French.

MINING EXHIBITION.—It is proposed to hold an International Exhibition of Mining and Metallurgy at the Crystal Palace in the summer of the present year. The classification will include machinery in motion; gold, silver, diamond, iron-stone and iron ore, lead, tin, copper, zinc, and coal mining; manufacture of iron and steel, petroleum industry, salt machinery, precious stones, alloys, explosives, scientific instruments used in mining and the metal trades, mining tools, &c. The Exhibition will open on the 2nd July and close on the 30th September. The hon. secretary is Mr. G. Ferguson, editor of the *Mining Journal*, and the offices are at 18, Finch-lane, E.C.

PROGRESS OF THE BASIC, OR THOMAS-GILCHRIST PROCESS.—The total make of steel and ingot iron from phosphoric pig during the twelve months ending 31st December, 1889, amounts to 2,274,552 tons, being an increase over the make for the previous twelve months of about 321,318 tons, and making the total production of basic steel to this date 10,845,000 tons. It will be noticed that of the above-mentioned make of 2,274,552 tons, no fewer than 1,764,639 tons were ingot iron, containing under 17 per cent. of carbon. The makes of the various countries for the twelve months ending 31st December, 1888, and 31st December, 1889, respectively, are as follows:—

	1 89.		1888.	
	Total tons.	With under 17 per cent. carbon.	Total tons.	With under 17 per cent. carbon.
England	493,919	348,828	408,594	276,476
Germany, Luxemburg, & Austria	1,481,642	1,185,323	1,276,070	1,026,033
France	222,39	159,271	222,333	158,223
Belgium and other countries	76,599	71,217	46,237	32,300
Totals... ..	2,274,552	1,764,639	1,953,234	1,493,032

With this 2,274,552 tons of basic steel were produced some 700,000 tons of slag (containing about 36 per cent. of phosphate of lime), most of which was used as a fertiliser.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

MARCH 19.—J. S. KELTIE, "Commercial Geography." SIR FREDERICK ABEL, C.B., D.C.L., F.R.S., will preside.

MARCH 26.—G. N. HOOPER, "Carriage Building and Street Traffic in England and France." COLONEL SIR NIGEL KINGSCOTE, K.C.B., will preside.

Papers for Meetings after Easter:—

DR. PERCY F. FRANKLAND, "The Aim and Scope of Higher Technical Teaching."

TALBOT B. REED, "Old and New Fashions in Typography."

FOREIGN AND COLONIAL SECTION.

Tuesday afternoons, at Five o'clock:—

MARCH 18.—JAMES W. WELLS, M.Inst.C.E., "Brazil."

APRIL 22.—SIR JOHN STOKES, K.C.B, "The Danube and its Trade."

A. LASENBY LIBERTY, "The Industrial Arts of Japan."

C. G. WARNFORD LOCK, "Gold Mining in Hungary."

INDIAN SECTION.

Thursday afternoons, at Five o'clock:—

MAY 22.—SIR J. THEODORE HOPE, K.C.S.I., "The Rationale of Indian Railways." The MARQUIS OF RIPON, K.G., will preside.

[The Meetings of this Section will in future be changed from Fridays to Thursdays.]

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock:—

MARCH 25.—W. J. LINTON, "Engraving in Wood, Old and New."

APRIL 15.—C. PURDON CLARKE, C.I.E., "Modern Indian Art."

MAY 13.—Prof. W. C. ROBERTS-AUSTEN, F.R.S., "The Use of Alloys in Art Metal-work."

CANTOR LECTURES.

Monday evenings, at Eight o'clock:—

A. H. CHURCH, M.A., F.R.S., Professor of Chemistry in the Royal Academy, "Some Considerations concerning Colour and Colouring." Three lectures.

LECTURE I.—MARCH 17.—Definition of terms. Constants of colour. Primary colour-sensations. Classification and nomenclature of colours. Luminosity of pigments. Translation of colour into white, greys, and black. Effects of varying illumination. Dichroism. The chromatic circle. Chromatic equivalents.

LECTURE II.—MARCH 24.—Complementary colours. Contrast of tone and colour. Harmonies of colour. Combinations of colour, dyads, trias,d tetrads, &c. Separation of related hues. Throbbing colonr.

LECTURE III.—MARCH 31.—Balance, proportion, and distribution of colour. Counterchange and interchange of colour. Colours of natural and artificial materials. Decorative and pictorial colour. Colour in relation to architecture and sculpture.

POPULAR LECTURES.

Saturday afternoons, at Three o'clock:—

Professor VIVIAN LEWES, "The Atmosphere." Four Lectures.

LECTURE II.—MARCH 15.—The preparation and properties of oxygen gas, the great supporter of life and combustion in the atmosphere. Nitrogen an inert gas which dilutes and tempers the action of the oxygen. The natural impurities always present in air. Water vapour and its importance to health and comfort. The traces of nitric acid and ammonia found in air, and the functions which they perform.

The regulations for admission will be the same as for the Cantor Lectures, each member having the privilege of admitting a friend.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MARCH 17...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Prof. A. H. Church, "Some considerations concerning Colour and Colouring." (Lecture I.)

British Architects, 9, Conduit-street, W., 8 p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

Asiatic, 22, Albemarle-street, W., 4 p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Rev. Canon Benham, "The Beginnings of Modern Europe." (Lecture II.)

TUESDAY, MARCH 18...SOCIETY OF ARTS, John-street, Adelphi, W C., 5 p.m. (Foreign and Colonial Section.) Mr. James Wells, "Brazil."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. G. J. Romanes, "The Post-Darwinian Period." (Lecture IX.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. James Price, jun., "Lough Erne Drainage."

Statistical, School of Mines, Jermyn-street, S.W., 7¾ p.m.

Pathological, 20, Hanover-square, W., 8½ p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Dr. Mivart, "The South American Canidæ." 2. Mr. R. I. Pocock, "A Revision of the Genera of Scorpions of the Family *Buthidæ*, with Descriptions of some new South African Species." 3. Mr. F. E. Beddard, "Some Points in the Anatomy of the Condor."

WEDNESDAY, MARCH 19...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. J. S. Keltie, "Commercial Geography."

Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Mr. G. M. Whipple, "A brief notice respecting Photography in Relation to Meteorological Work." 2. Mr. William Marriott, "Application of Photography to Meteorological Phenomena."

Microscopical, 20, Hanover-square, W., 8 p.m. Mr. A. D. Michael, "The Variations of the Female Reproductive Organs, especially the Vestibule, in different Species of *Uropoda*."

Archæological Association, 32, Sackville-street, W., 8 p.m.

National Indian Association, Exeter-hall, Strand, W.C., 4½ p.m. Mr. James Routledge, "The Young India of To-day: its Duties and Privileges."

THURSDAY, MARCH 20...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Mr. E. B. Poulton, "The External Morphology of the Lepidopterous Pupa." (Part II.—"The Antennæ and Wings.") 2. Prof. G. B. Howes, "The Intestinal Canal of the Ichthyopsidæ, with especial reference to its Arterial Supply."

Chemical, Burlington-house, W., 8 p.m. Prof. Judd, "The Evidences afforded by Petrographical Research of the Occurrence of Chemical Change under great Pressure."

London Institution, Finsbury-circus, E.C., 7 p.m. Rev. Canon Benham, "The Beginnings of Modern Europe." (Lecture III.)

Royal Institution, Albemarle-street, W., 3 p.m. Mr. F. Niecks, "The Early Developments of the Forms of Instrumental Music." (Lecture III.)

Electrical Engineers, 25, Great George-street, S.W., 8 p.m.

Historical, 11, Chandos-street, W., 8½ p.m.

Ladies' Sanitary Association, 22, Berners-street, W., 3½ p.m. Miss Chreiman, "Physical Training of the Young."

Numismatic, 4, St. Martin's-place, W.C., 7 p.m.

Camera Club (at the HOUSE OF THE SOCIETY OF ARTS), 2 p.m. Annual Conference. 1. Captain W. de W. Abney, Presidential Address. 2. Mr. A. M. Rossi, "The Art of Drawing and Photography." 3. Mr. T. R. Dallmeyer, "Limitations in the Treatment of Subjects by Focus." 4. Mr. Lyonel Clark, "The Influence of Stops on Exposure." 5. Mr. A. A. Common, "Eclipse Photography." 6. Mr. W. T. Wilkinson, "Collotype Practically Illustrated." 8 p.m. Exhibition of lantern slides.

FRIDAY, MARCH 21...Camera Club (at the HOUSE OF THE SOCIETY OF ARTS), 2 p.m. Exhibition of Apparatus. Conference continued. 1. Official Communication upon the Subject of Regulations for Photographic Exhibitions. 2. Lord Rayleigh, "Photography by the Light of the Electric Spark." 3. Captain Abney, "A Photographic Untruth." 4. Mr. C. H. Bothamley, "The Latent Image." 5. Mr. W. T. Wilkinson, "Photogravure Practically Illustrated."

United Service Inst., Whitehall-yard, S.W., 3 p.m.

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Prof. F. F. Fitzgerald, "Electro-Magnetic Radiation."

Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. L. A. Legros, "Economy Trials of a Compound Mill-Engine and Lancashire Boilers."

Philological, University College, W.C., 8 p.m. Prince L.-L. Bonaparte, "Albanian, Modern Greek, Gallo-Italic, Provençal and Illyrian still (1889) in use in the Neapolitan and Sicilian Provinces of Italy."

Quekett Microscopical Club, 20, Hanover-square, W., 8 p.m.

SATURDAY, MARCH 22...SOCIETY OF ARTS, John-street, Adelphi, W.C., 3 p.m. (Popular Lectures.) Prof. Vivian Lewes, "The Atmosphere." (Lecture III.)

Physical, Science Schools, South Kensington, S.W., 3 p.m. 1. Mr. Hubert Tomlinson, "The Villari Critical Point of Nickel." 2. Prof. Silvanus Thompson, "Bertrand's Idiocyclophanous Prism,"

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Lord Rayleigh, "Electricity and Magnetism." (Lecture VI.)

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FRIDAY, MARCH 21, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

POPULAR LECTURES.

The second lecture of the course on the "Atmosphere," was delivered on Saturday afternoon, 15th inst., by Professor Lewes. The lecturer showed the marked and distinctive properties of the two chief constituents of air, viz., oxygen and nitrogen, pointing out that in the chemical activity of the oxygen was to be found the source of heat and life on the earth's surface, the process of combustion consisting of chemical combination taking place between various so-called combustible bodies and the great atmospheric supporter of combustion, oxygen.

It was shown that all substances which would burn in air did so with exaggerated violence in oxygen, whilst many substances, like zinc and steel, which do not ordinarily burn short of an intense white heat, readily burn in an atmosphere of oxygen. At one time an idea was prevalent that an increase in the per-centage of oxygen present in the air would tend to increase its healthfulness, but it was found that this was not the case, and that pure oxygen at low temperatures was a virulent poison.

Nitrogen, like oxygen, is an elementary gas, and constitutes 79 per cent. of the atmosphere; in properties it is the antithesis of oxygen, being the most inert of gases, and showing but little desire to directly combine with other substances, its function in the atmosphere being apparently to dilute and keep within proper limits the activity of the oxygen. Besides these two chief constituents of the atmosphere, several other gases are always found present, and as they have distinct parts to play in the economy of Nature, they cannot be looked upon as impurities, unless they occur in sufficiently large quantities to affect health and comfort. These quasi-impurities are water vapour, carbon-dioxide, and traces of ammonia gas and nitric acid.

CANTOR LECTURES.

Professor A. H. Church delivered the first lecture of his course, entitled "Some Considerations concerning Colour and Colouring," on Monday evening, 17th inst.

The lectures will be published in the *Journal* during the summer recess.

Proceedings of the Society.

INDIAN SECTION.

Thursday, March 13, 1890; Sir Charles Turner, K.C.I.E., in the chair.

The paper read was—

AGRICULTURE AND THE STATE IN INDIA.

By W. R. Robertson.

In the Statistical Atlas published a short time ago by the Government of India it is stated at page 40 that "the Government of India, in addition to defending, ruling, and administering the country, is a landlord," and, in explanation, on the next page, that "of the £70,500,000 of revenue" received in the previous year, "the Government in its capacity of landlord received £20,500,000 by way of rental from the occupants of the soil."

India is essentially an agricultural country, but not in the sense that we speak of Canada, Australia, the Cape, or the greater part of the United States of America as being agricultural. These countries are agricultural merely because, comparatively speaking, they have been but recently settled, have as yet very small populations, and own vast areas of virgin soil, waiting only to be ploughed and sown to yield good crops. But in these countries there is abundant evidence to show that agriculture is gradually becoming less the predominating industry as the people are becoming more numerous; the agricultural stage through which these countries are passing being only that through which most advanced countries have passed. But India has long been agricultural, and, in spite of all that has been done in recent years to develop and foster other industries, there is every reason to believe that it will long continue to be almost exclusively agricultural.

The population of India is estimated to be now not less than 270,000,000, and its density not less than 200 per square mile.

Taking the whole of India, there are more people per square mile than in either France or the German Empire, and one-fourth more than in Ireland. The widely different position in which India stands as a corn-exporting country, compared with that of other corn-exporting countries, is at once seen when the densities of their respective populations are compared. In India the density of the population is ten times as great as it is in the United States of America, and six times as great as in the Russian Empire; while over Canada and Australia there are not as many people per one hundred square miles as there are in India per square mile. Over large portions of India the population is found to be over 600 per square mile, and in some districts there are as many as 800. In Bengal, the North-West Provinces, and Oude, which provinces have a total population more than twice as great as that of the United Kingdom, the density of the population is over 400 per square mile.

To secure a proper supply of food for the people of India in times of scarcity has, apparently, long been one of the most difficult problems connected with the administration of the country, even when the people were not one half so numerous; but difficult though the problem now is, its solution will become more and more difficult the longer is the delay in a real attempt to solve it. It might almost be thought a waste of time, in the face of the recent great development of India's export in food corn, to talk about the difficulty of feeding the people of India; but large though this trade undoubtedly is, the whole of the food corn now exported from India in a year would not feed the vast population of India for a longer time than about three weeks. The frightful famine in South India, so recently as 1876-78, during which not less than 5,000,000 of people perished from hunger in spite of the gigantic efforts made by the Government of the late Duke of Buckingham to provide food, and the declaration of the Supreme Government that neither effort nor money was to be spared to prevent the loss of a single life from famine, affords a sad illustration of the inability of a Government, even with the command of vast financial resources, to deal satisfactorily with a severe famine. The recent large development of railway systems will undoubtedly prove of immense advantage in future famines in bringing food from localities where it is more abundant into the districts where it is required, for it is fortunate that hitherto no famine has prevailed over the whole of India at one time. But when a population, numbering more than 7,000,000, must almost suddenly be provided with daily food and for a lengthened period, the work demanded in the carriage of the food is far beyond the capacity of any Indian railway. This was conclusively shown in the famine of South India.

But some may ask has not the large development of irrigation systems over India done much to protect the people from famine? Certainly, much has been done in this direction; there is no country that possesses such magnificent irrigation works as are owned by the State in India, but the fact nevertheless remains, that out of about 200,000,000 acres of land annually under crop in India, less than 30,000,000 acres are protected—and a considerable area of this only partially—by irrigation. More than 85 per cent. of the cropped area depends entirely on the rainfall. In most parts of India the crops are much more dependent on water supplied by rainfall or by irrigation than they are usually in most other countries, chiefly on account of the great evaporation, but also, to a large extent, because in the agricultural practice of the country the deep tillage of the soil, and the use of moisture absorbing and retaining manures, are but seldom resorted to. There is scope in nearly all parts of India for an enormous development of irrigation systems, not, perhaps, so much in the way of establishing those gigantic works on which so much attention has hitherto been devoted, as in minor works. In large portions of India the annual rainfall is more than twice as great as the annual rainfall of this country, and over considerable areas much greater. Indian rainfall shows such wide variations in amount and in distribution, that the problem is, how to preserve the surplus rain of one period for use when the fall is deficient. In Northern India irrigation works are, however, not so dependent on the fall of rain, as they draw their supplies largely from rivers fed by the melting snows of the higher ranges of mountains.

It has been calculated by competent authorities that the normal increase in the population of India is 1 per cent. per annum, that is, that every ten years, if there has been no unusual adverse influences at work to unduly check the increase, there will be added to the population at least twenty-five millions. In Bengal, the North-West Provinces, and Oude, the population during the ten years previous to the last census increased upwards of nine millions, or, at the rate of nearly 1 per cent. per annum; the increase over the remainder of India was nothing like this, but the scarcity and famine that prevailed during the decade in Southern and Western India fully explains this. We have, therefore, to contemplate the fact that in another ten years India may have a population of 300,000,000 to feed. The State has distinctly accepted the responsibility of protecting the people of India from famine, it having been authoritatively declared that famines must now be expected, and that, in providing for the ordinary administration of the country, a provision should always be made for contending with famines, and elaborate Codes have been drawn up for the guidance of the executive, in the endeavour to save the people when a famine prevails.

Amongst the many famine protective measures that have recommended themselves to those entrusted with the administration of India, it is, to say the least, remarkable that the development and improvement of Indian agriculture has received so little attention. It might have been thought that these subjects would have been the first to receive notice, but until about twenty years ago, when the Government of Lord Mayo earnestly took up the subject, the possibility that in an improving agriculture a means might be found for protecting the country from famine, appears to have been almost entirely ignored. It was specially unfortunate for India that Lord Mayo did not live to complete what he began so well, for there can be no doubt but that he would, before the expiration of his Viceroyalty, have organised on a sound footing the wise measures he then proposed to set in operation under State control for the improvement of Indian agriculture. So admirable was the programme drawn up under Lord Mayo's direction, that the Famine Commissioners, writing ten years later, and after a comprehensive inquiry into the condition of agriculture in India, adopted its main features and based their recommendations largely thereon. The opinions then held by the Government of India regarding Indian agriculture and the means that should be adopted to improve it, should not now be lost sight of, and it will, I think, be doing a great service to the cause of agricultural reform in India to bring these again into notice. The dispatch from which I shall quote is from the Government of India, is addressed to the Secretary of State for India, and is dated the 6th of April, 1870.

"Of all branches of Indian industry, agriculture, which constitutes the occupation of the great mass of the people, is by far the most important. We believe it to be susceptible of almost indefinite improvement. It is not necessary to dwell upon the obvious and vital necessity of increasing in every practicable way the supply of food available for the people of India. How this consideration affects all the prospects of the permanent material advancement of the country has, of late years, been painfully and repeatedly shown by the late famines which have taken place, and to the recurrence of which we shall ever be liable until the production of cereals is rendered more certain, and the facilities of conveyance immensely developed. For many generations to come the progress of India in wealth, and in civilisation, must be directly dependent on progress in agriculture. In India, agricultural and commercial progress go together. Agricultural products must long continue to constitute the most important part of our exports, and the future development of Indian commerce will mainly depend on the improvement in the quantity and quality of existing agricultural staples, or on the introduction of new products, which shall serve as materials for manufacture, and for use in the industrial arts."

"The efforts of the Government of India, and of English enterprise in such a direction, have doubtless been very beneficial in their results. Thus, important progress has been made in regard to cotton. Large sums of money were spent in former years in attempts to improve its cultivation, but with little useful result, owing to the mistaken system under which they were made. Renewed attention has been more recently given to this subject, with much better effect, and the extreme importance of doing all that is possible to improve and develop the cultivation of this great staple is fully recognised by the Government. Jute, which not long ago was hardly used, has become an article of first-rate commercial interest. The partial success of our tea, coffee, and cinchona plantations shows what has been and may be done in introducing into India new and valuable products; the world derives from India nearly the whole of its supply of indigo. Other illustrations might be given to the same effect, but, speaking generally, it cannot be denied that Indian agriculture is in a primitive and backward condition, and we think that it must be admitted that the Government has not done for its improvement all that it might have done."

"To state exactly what measures the Government ought to have taken in the past, or what course it should follow in the future, is undoubtedly not easy. It is hardly too much to say that scientific knowledge of agriculture in India has at present no existence. The common belief has been that the natives of this country can, in respect to the processes of agriculture, derive little or no benefit from any instruction which European science can give them. Such a belief rests, perhaps, upon observation of the obvious progress which has been made in many of the elementary requirements of agriculture in regard to tillage, rotation of crops, and so forth. But it has often been lost sight of that this sort of knowledge is only rudimentary and empirical, and that recent experience in all parts of the civilised world show conclusively that there is no branch of industry in which the effects produced by the intelligent application of science are more certain or more remarkable. We cannot doubt that when the light of science has been properly brought to bear upon Indian agricultural experience, the results will be as great as they have been in Europe." With regard to the improvement of stock, Government acknowledges having done little for the country at large, though a superior class of cattle and horses have been introduced and bred for military purposes. "Besides what has been done for tea, coffee, cotton, jute, &c., the cereals of this country demand similar attention. Rice, wheat, and other grains are often of an inferior description, and by the careful introduction and continued use of selected seed of a superior quality, great improvements might unquestionably be made. The same may be said of oil-seeds, pulses, and other products."

In these quotations we have an excellent programme of objects and aims for the guidance of a State policy in dealing with the vast agricultural interests of the empire. The opinions set forth are so sound, and the views as to what should be attempted explained in other parts of the despatch are so clear and definite, that there remained nothing to do but to give them effect through the agency of the machinery the Government proposed to create. The Government of India of that day recognised fully that they possessed abundant stores of information regarding the agriculture of the country in all its varied aspects, and that what the exigencies of their position demanded was not more and mere aimless and endless agricultural inquiries, and further additions to their vast stores of agricultural reports, but action on definite lines, with definite aims and objects, based on the stores of information they had already at their command. Unfortunately, the Home Government did not agree in the proposals of the Government of India, and, at the present day, the position remains much the same, though there has been inquiry after inquiry, report added to report.

But, at the time to which I am referring, the Supreme Government did not stand alone in the desire to institute measures for the improvement of agriculture, for, in a varying degree, the Governments of all the Provinces shared in the desire, and none more so than that of Madras, then presided over by the Right Honourable Lord Napier and Ettrick. That Government considered that however desirable it might be to possess further information on some points connected with native agriculture, the time for work had fully arrived, and that they could no longer defer taking direct action in attempting to improve the farming of the Presidency. To show how very sound were the conclusions they had formed, and in what a practical manner they proposed to carry them into effect, I venture to invite your attention to a programme in which the Madras Government formulated for the guidance of their agricultural officers the objects they should hold in view in carrying on their duties:—

"To ascertain, by experiment, the proper use of rotation in crops in this country.

"To introduce the system of root or green-crops in lieu of fallow, without artificial irrigation.

"To introduce new crops.

"To provide new kinds of seed, and fresh seed for the crops now cultivated.

"To make experiments in the use of water for the cultivation of crops now termed 'dry' crops, and for raising grasses, and other crops to be used as fodder.

"To make experiments in the use of lime and other manures—mineral and animal.

"To introduce new and improved implements of rural labour.

"To improve the working cattle, sheep, horses, and other varieties of live stock in the country."

What better programme of objects could now be framed, did India possess a real agricultural department, properly organised, and provided with the requisite funds. There need not be a single day's delay in framing a sound policy for the guidance of the State, in an attempt to benefit the great agricultural interests of the empire. The Famine Commission Report, submitted nearly ten years ago, is most exhaustive, in this, every phase of the agricultural question of India has been considered, and full and definite suggestions made as to what the State should do in order to fulfil its duties to the land; and I need scarcely remind you that the agricultural representative on that Commission was Sir James Caird.

But perhaps it may be expected that, as I have spent nearly twenty years in India as a Government agricultural officer, I should have some conclusions of my own to lay before you as to what can be done, and should be done by the State to improve Indian agriculture. I must, however, point out that I have already read three papers on Indian agriculture before this Society, in which I have stated very fully my own views. But there are some facts which, in the interests of Indian agriculture, cannot too frequently be brought into notice in this country, and I venture to bring some of them again before you, though they may be well known to many present. First, I would refer to the State "in its capacity of landlord." In all countries there are certain duties attached to the ownership of land as well as rights. Probably a quarter of the land revenue of the Government of India is yielded by land over which they have no direct control, this land being leased in perpetuity subject to the payment of a small fixed yearly quit rent. However, over at least one-half of the land under cultivation in India, the State is absolute owner, and exercises as full rights of ownership as any landlord over his land, subject to the custom of tenant right. Every landlord naturally desires not only to preserve but to enhance the productiveness of his estate. I need not point out to you how fully this is secured in this country by elaborate "farm agreements," "customs of the country," "Agricultural Holdings Act," &c., and by the employment of men in the management of landed property who have been specially trained, and are duly qualified for the duties. Unfortunately, the interests of the landlord and the tenant are not always identical; the tenant may desire to take all he can out of the soil he rents, regardless of the fact that he may thereby seriously reduce the intrinsic value of the land. Restrictions in cropping, when injudicious and carried to excess, are undoubtedly serious evils, but because the system may be abused it does not follow that absolute freedom in cropping is desirable in all cases, as far as the interests of both landlord and tenant are concerned. We have in India "nationalised land" in the fullest sense of the term, and it must be remembered that any depreciation in the value of this land reacts immediately on the interests of the State, and, indirectly, is prejudicial to the interests of every inhabitant of the country. In India no attempt whatever is made to protect the interests of the State in its vast landed property; its tenants can farm just as it pleases them, each one may crop with a corn crop every acre of his farm annually if he thinks fit, and he may relinquish in any year any field or fields for which he does not feel disposed to pay a rent, and may resume possession of each or all at his pleasure. But more remarkable still is the fact that, though the State expends annually considerably more than £3,500,000 sterling on the salaries and wages of the vast army of officials employed in collecting the rent, and in the management of its great property, it demands of those it employs not even an elementary acquaintance with the principles of agriculture, though it prescribes elaborate regulations for ensuring that they possess knowledge of other kinds, of Greek plays amongst other subjects. Surely, in this respect, some improvement is possible. I feel sure that if a knowledge of agriculture was deemed essential to secure employment in connection with land administration in India, there would be no difficulty whatever in securing fully qualified men. It must be evident to all how great an improvement might be effected in the land administration of the State were the officers employed duly qualified for their work; and how much more easy it would then be to introduce improvements in the husbandry of the people.

The next subject to which I would invite your attention is the cropping of the land in India. When we examine the agricultural statistics of the United Kingdom, we find that only about one-third of the cultivated land is under crops which are sold and removed from the land; but, on referring to the agricultural statistics of India, we find that such crops constitute fully 95 per cent. of those grown, and when we come to examine more closely these statistics, we learn that corn crops form more than 85 per cent. of these crops. In agriculture, we designate such crops exhaustive, for the simple reason that in them a large proportion of the fertility of the soil is removed. When a crop produced on a farm is consumed on the farm by its live stock, we term such a crop a restorative one, because the greater part of the fertilising matters the crop in its growth took from the soil are again restored to it. In this country, fully two-thirds of the cultivated area is under the so-called restorative crops, while in India not more than 5 per cent. of the cultivated land bears such crops. In all good farming the aim is to produce a large area of restorative crops; and, in most farm agreements, elaborate covenants are entered to secure this object.

What landlord in this country would be content if, from neglect or the want of knowledge on the part of his agent or steward, each farm on his estate was cropped over nine-tenths of its area, year after year, with corn crops almost unmanured. It is perfectly true that in producing three acres of corn crop the Indian farmer does not take more out of his soil than the farmer of this country does when he produces a single acre of corn, but then, the British farmer applies to his soil such a quantity of manure as usually much more than replaces the fertilising matters removed in his crop. The large proportion that corn crops constitute in the cropping of India is undoubtedly due to the great demand for food for the vast population of the country. Many Indian cultivators urge against the culture of green and fodder crops, that they want all their land for raising their own food, and for growing produce for sale to raise cash to pay the rent. When we remember that the average yield of corn crops in India is less than 8 bushels per acre, it becomes very evident that by simply increasing the yield per acre we can set a large area of land free for the production of fodder and green crops without in any way lessening the food supply of the people. This matter is one of very great importance, and demands urgent and serious attention.

I would next direct your attention to the tillage of the land. The latest statistical abstract of British India shows that on an area of 140,000,000 acres of cultivated land, regarding which only figures are available, more than 10,000,000 ploughs are employed, thus giving an average of 14 acres tilled by each plough. In this country the average area under tillage per plough cannot be less than three times as much. It might, therefore, be contended that tillage in India is much more thorough than it is in this country. It requires, however, but a short experience in India for any one to learn that such is not the fact. There can be no doubt whatever but that, if everything is taken into account, it costs the Indian farmer much more for effecting the tillage of his soil than it costs the British farmer for much superior work. The latter, with one operation of his plough and harrow, can ordinarily produce far more efficient and thorough tillage than the Indian farmer can, by ploughing his land half a dozen times. In the Report on "Bombay Crop Experiments" for 1887-8, just published, it is stated that in producing a crop of jowari, which is an inferior cereal largely grown, the cost of tillage alone is over Rs. 7 or about 70 per cent. of the entire cost of producing the crop. The Indian farmer effects his tillage by repeated ploughings — sometimes as many as ten or twelve. Estimating the hire of a pair of bullocks at 6 annas per day, and that of the driver at 3 annas, we get a total daily cost of 9 annas, while the area ploughed—if I may so call it, for it is cultivated rather than ploughed, the soil being stirred only and not turned over as in ploughing—is less than one-third of an acre. The cost per acre then of this so-called ploughing cannot be put at less than Rs. 1 as. 11, and for six operations the total cost per acre will be more than 10 rupees, and this, it must be remembered, is for the tillage of only the upper four inches of soil. Of course the largest proportion of the arable land is not ploughed oftener than two or three times for a crop. I have no hesitation in stating that, over India generally, the cost of tillage might be reduced greatly, and be done far more efficiently, by the general introduction of improved tillage implements. But other advantages besides the reduction in the cost of tillage would attend the use of improved implements; one of these would be the greater expedition in doing work, a matter of the greatest importance in the preparation of a seed-bed in India, when the delay of a single day in getting in the seed may result in the loss of half a crop; and in securing deep tillage there would be great economy. Deep tillage is but rarely practicable in India when native implements only are used, on account of the great cost and the tediousness of the operation. I need not enlarge on the many advantages of deep tillage in a tropical climate.

The manuring of the land is the next point to which I would draw your attention. Judging by the remarks that are sometimes made on this subject, it would almost seem as if some people thought that the laws of nature operate differently in India than they do elsewhere. Such ridiculous statements have been made as that manures are not needed by Indian soils. It is true that large areas of country have produced satisfactory crops for a long period without a direct application of manure, but such land has invariably received regular and full supplies of manure annually in the silt left by the irrigation water. Over large tracts of upland country, portions of the soil are annually carried away by the surface drainage during heavy rains into the rivers, by which it is conveyed to the land irrigated. In this way considerable areas of land are benefited at the expense of other tracts. But great though is the area of the land so manured, it does not constitute more than 5 per cent. of the land in India that is annually under crop. The rapid and large increase in the area of ploughed land, and the corresponding decrease in the area covered by wild grass and scrub jungle, is a matter to which I have again and again invited your notice; and I am glad to find that Sir James Caird, in his book, "The Land and the People of India," has amply confirmed my views. Figures showing the increase in the area of the ploughed land are not available for the whole of India, but such figures are forthcoming in connection with the Madras Presidency, and from these we learn that in 30 years the area there of ploughed land has increased from 19,562,897 to 28,790,000 acres, that is nearly 9,000,000 acres. When it is remembered that hitherto the farm stock of India has been maintained very largely by the food obtained on the natural grass land, and in the scrub jungles, and that the Indian farmer never sows grass seed for making a pasture, or grows fodder crops for his stock, except in rare instances, the loss to native agriculture in the diminution of their natural supplies of food for cattle and sheep will be appreciated. Of course, unless the native farmer takes to sowing grass, roots, and fodder crops, the gradually lessening supplies of food on which he has hitherto depended for maintaining his stock, will compel him to reduce his stock. The Madras agricultural statistics, the most accurate of those available, show clearly a gradual decrease in the farm stock of the Presidency, per 100 acres of cultivated land, and of course the supplies of manure will be diminished. We have thus to face the fact of a large and steady increase in the area of the arable land, that is, land necessarily requiring manure, while there is a corresponding decrease in the area of land which hitherto has chiefly fed the farm stock from which nearly the only manure used was obtained. It is difficult to compare closely the manurial force as represented by farm stock in India with that of this country; but such a comparison, imperfect though it may be, brings out clearly some very important facts. Thus, as regards sheep, which as manure-producing stock are very highly valued in the former country, we find that India possesses, including goats, a flock of only about 25,000,000, for her 200,000,000 acres of crops; whereas in the United Kingdom, with a cropped area only one-fifth so large, there are 30,000,000 of sheep, and each of these it must be remembered is twice as large as an ordinary Indian sheep. As regards cattle, there are, as would be expected, seeing that they are used almost exclusively in India in the tillage of the soil and in road traffic, a larger number per square mile of cultivated country than there are in the United Kingdom. But it must not be lost sight of that two average Indian bullocks will not weigh more than one average English bullock, while there must be an enormous difference in the value of the cattle manure in the two countries, seeing that cattle are always so well fed in this country, and so inadequately fed in India. Further, while India exports an enormous quantity of cattle food, and manures in the shape of bones, saltpetre, oilcake, &c., the United Kingdom imports such materials for agricultural use annually to the value of £5,000,000 sterling. It is difficult to say what proportion of the cattle manure in India really is used on the land, the use of cattle dung as fuel being so general; but over large tracts of country from one-third to one-half is so used, and but a very small part of the ashes of the dung find their way to the land. The Indian farmer seldom makes any use of town refuse, and uses neither lime, saltpetre, nor bones, although the two latter are largely exported from India for agricultural use in other countries. The only manures he uses to any extent, besides stock manures, are oil-cakes, certain wild plants and leaves of trees, and sometimes he grows a green crop for ploughing in. Sir James Caird stated the conclusions he arrived at on this question after, as a member of the Famine Commission, he had made a thorough examination, as follows :—

"The agricultural system, except in the richer and irrigated lands, is to eat or sell every saleable article the land produces, to use the manure as fuel, and to return nothing to the soil in any proportion to that which is taken away . . . . Crop follows crop without intermission, so that Indian agriculture is becoming simply a process of exhaustion."

These views are in entire agreement with those regarding Southern India I laid before you in the paper I read in the early part of 1880.

On the question of irrigation, I shall not detain you long. As I have already pointed out, not more than 15 per cent. of the cropped area of India is irrigated; but of this only one half is by canals that supply the water directly on the land without the necessity of it being lifted; much of the remainder is irrigated from wells, the water of which has to be laboriously raised from a depth varying from 20 feet to 50 feet. There is, of course, a wide difference in the agricultural value of water supplied by canals, which is frequently largely laden with fertilising silt, and which, generally, the cultivator can obtain in abundance, by no more trouble than opening a sluice, compared with the clear water of wells, which has to be lifted with so large an expenditure of labour. But irrigation wells have proved invaluable in India, for though in a dry season their supplies are diminished, this does not take place to the same extent as in rivers and tanks. But a cheap and efficient machine for raising irrigation water from wells is still a great want in India.

I have frequently drawn attention to the enormous waste of irrigation water when the cultivator obtains his supplies by merely opening a sluice. The one desire of the ryot appears to be to get the largest possible quantity of water for his land. Direct observations have repeatedly shown that in growing a crop of rice a volume of water is used equal to a depth of 10 feet or 12 feet over the whole area cropped. Careful experiments made under similar circumstances, have decidedly proved that, ordinarily, as good crops can be obtained by an expenditure of one-half this volume of water. But not only is there an enormous waste of irrigation water by its wasteful lavish use, but the full effect of the water is but seldom obtained from the shallow tillage of the soil, and the very limited use of organic manures. If the ryot could be induced or compelled, to use the water supplied to him by the State with the economy that characterises his use of the water he laboriously lifts from wells, the area of land benefitting from irrigation might be widely extended in India. I need scarcely say that the health of the people would be greatly improved, for there is an excessive mortality in India from fevers, due largely to the insanitary conditions produced by swamping the land in irrigating it. There is nothing that would more largely contribute to the prosperity of Indian agriculture than a large increase in the area of land under irrigation. Seeing what vast sums the State has laid out in irrigation works, its interest in the proper use of the water it supplies to its tenants, is very obvious, without taking into account the protection a large irrigated area affords against famine.

Regarding Indian farm stock I need not say much. All authorities agree in deploring the general neglect the Indian farmer exhibits in the management of his stock. I have already quoted from the "Statistical Atlas" of India, and I venture to invite your attention to another quotation from that work :—

"The cattle in most parts are half starved. One of the saddest sights in India, as we travel for hundreds of miles by rail, in the second quarter of the rainless months, is to see the cattle standing without food and almost without shade, exposed to a scorching heat in the midst of arid plains bare of sustenance. Meanwhile the strength of the cattle, on which the tillage operations of the forthcoming season depends, is of course frightfully diminished every day the rain holds off. Sometimes the delay is, as it was in 1877, so great that cattle died in thousands and even millions. In one district for instance, 250,000 disappeared out of 500,000."

Remember this description is not mine, but I consider it a very accurate one. As a general rule Indian stock are left very much to their own resources for obtaining food. When there was plenty of good unoccupied land near at hand covered by wild vegetation, on which stock could feed, this was not so objectionable.

But there are now few localities in which the unoccupied land affords a sufficiency of food for the farm stock of the neighbourhood. What is greatly wanted everywhere is fodder crops, and there are few countries so well provided as India is with good indigenous crops suited for producing fodder. Many of these produce enormous yields of really excellent fodder, grows very rapidly, and are produced at an extremely low cost. But the Indian cultivator sees no reason why he should provide against the hunger of his stock, for he has himself so frequently to experience the discomfort and pain of not having sufficient food. He has not yet learned that the enormous mortality amongst his farm stock is due chiefly to inadequate feeding, and that his tillage operations in the sowing season would be greatly facilitated and cheapened if, by growing fodder in the dry season, by the limited use of irrigation water, he maintained his cattle in good condition.

In the improvement of Indian races of farm stock very much can be done without incurring a large expenditure. Many of the breeds of cattle possess points of considerable excellence, which only need to be developed and established by the exercise of judgment in breeding. Dairy races of stock might readily be established by such means in all the Provinces, for cows with latent milk-producing characteristics are to be found of nearly all the chief breeds. When it is remembered that milk forms an item of the daily food of all classes in India, it will be recognised how important it is that attention should be given to the improvement of milch stock. The average yield of milk of an ordinary cow is not more than two quarts daily; it will be seen, therefore, what room there is for improvement. Over a great part of Southern India the draught bullocks do not on the average weigh more than from 300 lbs. to 400 lbs., which is but little more than the weight of a good Cotswold sheep. In the Madras Presidency there are one or two breeds of cattle of some excellence, but many ryots do not care to possess animals of these breeds, as they say such stock is too costly for them to keep, for they "must be fed," whereas their diminutive cattle, like goats, can meet with a subsistence almost anywhere. Something has been done by means of agricultural shows to encourage more attention in the breeding and the management of farm stock. But a great deal more might be done in this direction at a very moderate expenditure of State funds. These shows have neither been held with sufficient frequency nor in as many localities as they ought to have been.

The only other subject to which I would refer on the present occasion is agricultural education, and I will also deal with this question very briefly, for I hope some day soon to read a paper devoted specially to this question. All I desire to do now is only to urge the supreme importance of the subject in an agricultural country such as India. The Government of India now expends several millions annually in developing the minds of Indian youths, but has hitherto been very reluctant to expend anything on the special education of those who, in the rents they pay, contribute so largely to the welfare of the State. On this subject I cannot do better than quote again from the despatch from the Government of Lord Mayo, from which I have already so largely quoted:—

"In their well-known despatch of the 19th of July, 1854, on the subject of education in India, the Court of Directors referred with approval to proposals that had been made for teaching practical agriculture. They said "that there was no single advantage that could be afforded to the vast rural population of India that would equal the introduction of an improved system of agriculture." Unfortunately the means of obtaining agricultural instruction are no better now than when this dispatch was written fifteen years ago. We do not disguise from ourselves the difficulty of affording to Indian landlords and cultivators the means of obtaining scientific and practical knowledge for improving agriculture. But the difficulty of the work ought not to discourage the Government from doing everything in its power to develop this important branch of education.

With the example afforded by almost all civilised Governments, it is surprising that the State in India, which in other respects so readily adopts measures for the improvement of the material interests of the people has done so little to place instruction in agriculture at the disposal of the millions in India dependent entirely on this industry, and whom it has undertaken to protect in time of scarcity, when their agriculture fails them. The merely literary education on which the State spends so vast a sum has proved disadvantageous to India agriculture in many respects, chiefly in drawing away from agriculture thousands of the more enterprising youths who, after obtaining a smattering of literary knowledge, come to look with contempt on the husbandry with which their forefathers have always been connected. If the energies of such youths were directed into useful channels, there would not be such grounds for regret, for it certainly is desirable that some portion of the agricultural community should seek a livelihood in other occupations; but if the best men leave agriculture, and no effort is made to improve the knowledge of those who continue to be dependent on the soil, it is evident that but one result can follow, the further degradation of agriculture. That the landed classes in India would welcome the establishment of a sound system of agricultural instruction the experience in Madras amply proves. When the College of Agriculture was opened there, nearly fifteen years ago, students came to it from all parts of India, and most of them were connected with the land as owners or occupiers. But what can one Agricultural College do for the whole of India? Each Province should have a properly organised agricultural college established on a sufficiently extensive scale; and in all rural schools the principles of agriculture should be taught. Were such instruction given, merely in view to secure a knowledge of agriculture in those whom the State employs in the management of its vast agricultural property, there would be ample employment for many agricultural schools and colleges in India, and ample justification for the expenditure of State funds in their maintenance. But this is much too narrow a ground on which to urge the claims of agricultural education on the attention of the authorities who administer the affairs of India. This subject is far too important to justify me in dealing with it more fully to-night, and I have already occupied your attention too long. But before closing, I would briefly summarise a few of the points and conclusions that should not be lost sight of:—

That the Government of India is landlord-in-chief in India.

That India is essentially an agricultural country.

That India has an enormous and very rapidly-increasing population.

That famines in India will become more severe and more difficult to contend with as the people become more numerous, unless efficient means are taken to improve the material condition of the people.

That for famine protection purposes, railways and irrigation systems are useful, but that the improvement and development of agriculture is of far greater importance.

That the Government of India possess already much valuable information regarding the state of agriculture in India, and as to what might be done, and should be done to improve it.

That what is now so urgently wanted is an active agricultural policy working on definite lines, with definite aims and objects.

That the cropping of the whole country is very severe and exhausting.

That the growth of grass and fodder crops should be encouraged.

That improved implements suited to the conditions of the country would facilitate and cheapen tillage.

That a large area of the land is cropped without manure, and that many valuable manures available in the country are not made use of, while there is a great waste of manurial matters.

That the natural supplies of food for farm stock are gradually becoming less; that as a result fewer stock is kept, and there is a consequent loss of manure; while the area of ploughed land, that is, land needing manure, is increasing.

That means of irrigation should be greatly increased.

That the cultivator should be induced or compelled to use State supplied irrigation water in a less wasteful manner; and lastly,

That a good system of agricultural instruction should be organised, and be maintained by the State in every province of the Empire.

DISCUSSION.

Sir CHARLES BERNARD said the Society was much indebted to Mr. Robertson for this paper. He was the first professional agriculturist who went to India, where he did an immense deal of good in Madras by means of the investigations he conducted, and through the college he started and maintained for so many years, and where a number of pupils were trained who had been most usefully employed since, both by the Government and by independent zemindars. He hoped that the lessons he had enforced would be acted upon and receive proper attention at the hands of the authorities, for no one could exaggerate the importance to India of agriculture. It was true in one sense that the Government was landlord over a great part of India, as it drew a large revenue from the land, but he did not think the Government could be considered the landlord in the same sense in which the term was employed in England, or that it could insist on the rotation of crops, or impose restrictions on the ryot, who, with all his ignorance, notwithstanding the many reports which had been issued on the subject, probably knew best what to grow. But the Government had not altogether neglected its duty, for it had expended in the last thirty years nearly £200,000,000 sterling on railways, nearly £30,000,000 on irrigation, and £100,000,000 on roads, and those who knew India best all said that this money had done a great deal of good. It had certainly increased immensely the cultivation and export of all sorts of agricultural produce, and presumably the wealth of the country. The reader of the paper had urged that agriculture in India needed to be more intensive, but the change could not be wrought by the introduction of foreign methods, but by the study of the native methods and then the improvement of them. The improvement must come on Indian lines, and that was why the education on which Mr. Robertson laid so much stress was so important. When the Indian farmers learned something of scientific agriculture, and how its principles were applied elsewhere, they would be able to apply such knowledge to the methods they had inherited from their fathers. The importation of steam ploughs and similar implements would not materially benefit the cultivators, but it would benefit them to teach a large number the true principles of the science and how to apply them. Stress was often laid on the enormous difference between the produce per acre in India and in England, in the case of wheat being 9 to 9½ bushels as against 30; but it was hardly possible within any reasonable time to see the produce in India come up to anything like the English standard. Those countries which had a surplus of food were always those which had a small yield per acre and a large area under crop, *e.g.*, India with 9½ bushels, America with about 11, and Australia with about 13, as compared with 30 per acre in England. The cost of growing that wheat in India was probably under 5 rupees per acre, while in the United Kingdom it would be from £4 to £5; and he could not look forward to the time when the Indian agriculturist, with the aid of manures and better knowledge, would expend anything like that sum per acre. They would have to follow Sir J. Caird's advice, and endeavour to increase the food produced by one or two bushels per acre, and that was as much as could be hoped for. The annual food crop was obtained from about 185,000,000 acres, and if that were increased by one bushel per acre it would do an immense deal to provide the people with more food, to enable them to feed the cattle better, and to lay up a store against years of famine. In some points he thought Mr. Robertson had exaggerated the deficiency of stock. He had been looking up the statistics that afternoon, and found the figures were as follows:—

	1882.	1888.
Madras bullocks	7,140,000	9,083,000.
Bombay ,,	5,656,000	6,476,000.
Punjab ,,	6,121,000	9,000,000.
Madras sheep	5,500,000	9,500,000.

That looked as if the stock were not really decreasing, though of course returns were not always correct. The other day he came across a settlement report from the Deccan of a tract which had suffered very severely in the famine of 1877, and the figures were very interesting. In 1851 there were 19,000 cattle, and before the famine of 1877 there were 25,000. The next year there were only 15,000, but in 1888 they had gone up again to 20,000, so that the stock did recover itself, even though depleted from time to time by these terrible famines. The Government had been doing something for agricultural education by establishing colleges both at Madras and at Poonah; the former had somewhat gone down since Mr. Robertson had left, but the latter had been greatly strengthened, and in many districts the Government had helped to improve the breeds of cattle by importing bulls from districts where the cattle were better; the same with horses, and to some extent with sheep and mules. With regard to famines, the improvement of communications had done more than Mr. Robertson perhaps thought to mitigate the evil; but if there were another famine like that of 1877, no efforts on the part of the Government could prevent a great mortality Happily, these great famines did not occur oftener than once in a century, but when they did, nothing would prevent great loss of life. The addition of a bushel or two to the produce per acre would not enable the people to get through a bad year when the crops failed entirely, and the extra two bushels of a good year, instead of being hoarded, would have left the country. At the same time, every addition made to the yield would benefit the famine-stricken districts in this way, that a failure was never universal, and the surplus of other provinces would go to fill up the gap by means of the railways and roads of which he had spoken. It was unfortunately true that the people misused a good deal of manure, but as far as they could spare it they used it to the best advantage; and the cultivation of forests, whereby other fuel was provided, would aid a great deal in promoting the use of manure. By-and-bye, he hoped coal would be used as fuel, and then all the animal manure would be set free. A good deal of bone manure was used on the tea and coffee lands, but not as yet by the ryots, and last year as much as 35 tons of bones were exported from India. With regard to fodder, though there were no crops grown specially, it must be remembered that some of the grain crops, and especially the greater millet, yielded about 40 or 50 times as much fodder as grain, and on that the cattle were fed. Although he had ventured to remark on some points in this most valuable paper, he wished to bear testimony to the immense good which Mr. Robertson had done by his persistent advocacy of agricultural education and improvement.

Sir JOSEPH FAYRER, K.C.S.I., F.R.S., desired to thank Mr. Robertson for this paper which, though perhaps open to criticism in some details, had the great merit of putting strongly before the public the impressions formed by a man who knew the wants of the great country with which he was dealing. No one could have lived long or travelled much in India without seeing how much improvement in agriculture was needed; and that not so much by the introduction of English implements as by the improvement of native methods. The time was probably far distant when English steam ploughs would be introduced; the cultivator would still take his plough on his shoulder to the field, and bring it home again in the evening, for a long time to come. It was quite true that the ground was not turned over, it was merely scratched, which did not much add to its productiveness. There was not much manure, and what there was, was chiefly used as fuel. Important measures were being taken for restoring the forests, which up to 1846 had been neglected, and even destroyed; and if anything would prevent famines, and restore the fertility of the soil, that was the way to do it. Whatever tended to develop the growth of forests and the cultivation of crops, grass, or any other vegetable matter would tend to improve the health of the country by tempering the climate and regulating the rainfall. India depended mainly for its rain on the great monsoon system; when it occurred regularly and was not counteracted by contrary winds, there would be no famine, but there might be local drought, and where the forests and vegetation were destroyed there would inevitably be a deficiency of moisture, dry and arid land, and a low state of cultivation, and when unusual droughts occurred, famine might be expected. The effects of afforestation in modifying the climate have been shown in many instances; as far back as 1846 or 1847, *e.g.*, a detachment of troops was sent to the frontier of Scinde under Colonel Jacob; he came to a place where there was about one tree growing, the temperature was 125°, the sky was like brass and the earth like iron. He determined that all this should be altered; he gave his life to it, and lived and died there, but he succeeded in restoring the place to something like the condition in which it may have been in ancient times. He began by making a small conduit from the Indus about 40 or 50 miles distant, and then planted trees, and it was soon apparent, as had been found elsewhere, that no soil was more fertile than those deserts when irrigated. For instance, the Memorial Garden at Cawnpore was an example of the luxuriance which, by the use of water, could be substituted for desolation. General Sir Henry Green told him the other day that when he left this settlement in Scinde towhich he had alluded, Zacobabad, it was a fertile spot, abounding in trees, and the rainfall had increased from 1½ inches per annum to 3, 4, or 5 inches, and the temperature reduced. There was little doubt that the desert regions of the North-West were at one time the seat of a great Hindoo civilisation, but the rivers had even disappeared, swallowed up by the sand, in the same way as the Scamander in the Troad had disappeared, and the Euphrates had been diminished, by deforesting and the destruction of vegetation, whose presence tempered the air and modified the climate, making the hot days cooler, and the cold nights warmer, and increasing the rainfall. He had been much gratified at hearing the recent paper on "Forestry," though he thought it might have contained a more ample reference to the labours of the earlier workers in that field; such as Gibson in Bombay, Cleghorn, the father of scientific forestry, and Michael, the pioneer of practical forestry, in India. He believed men like Mr. Robertson would do as much good with reference to agriculture generally as they and their successors had done and were doing for forestry. There were no two departments of the Indian Government more important, and none on which the ultimate welfare and health of the country more depended. As had been pointed out, the manure was not used as it should be, whilst the refuse from the villages accumulated in heaps, and produced disease, instead of being applied to give fertility to the soil. Irrigation, again, was a most important question, and though the good it produced was recognised, there was often an outcry against it, on account of the illness which was said to follow it. There was no doubt that high death-rates occurred where irrigation was most profuse, but that arose because the works were not properly managed; there was too much water, and too little vegetation, and insufficient subsoil drainage. The main cause of fevers which caused the great mortality in India was, generally, stagnant subsoil water, wherever and however produced. In some places, also, where there was too much water, it brought to the surface certain salts of sodium and potassium, known as "reh" in India, which sterilized or deteriorated the soil, and caused damage; but a better regulation of that very water would fertilise the soil without injuring the public health.

Mr. McDougall said he had had considerable experience of Indian wheat, some of which was equal to the best in the world, but the great difficulty was in the way in which it was harvested and sent to market. With very few exceptions, the samples which came here contained very great admixture, whether from carelessness or from growing two or three kinds of grain in the same field he did not know, but it greatly reduced the value. The great competitor of India in the corn market was America, and there a great step had been made in advance in the way in which the wheat crop was collected. The farmer need not store his wheat on his farm, or even take samples to market; the railway companies and elevator companies provided receptacles to receive it, and gave warrants for so much produce of a certain quality, which the farmer could deal with at his pleasure, only paying a small sum for rent and interest. The Indian cultivator, on the other hand, had to take not only his samples, but his whole produce to market, and owing to the unsatisfactory condition in which it reached this country, though of first-class quality, it did not fetch the highest price.

Mr. W. MARTIN WOOD said there was no need for Mr. Robertson to apologise in again bringing this subject before the Society, as it required to be insisted on again and again. He was glad to see that more and more attention was being paid to it, especially with regard to improving the quality and number of stock. Sir Charles Bernard had taken rather a hopeful view of the question recently raised by Dr. Steel in a lecture at Poonah, "Is the number of cattle sufficient for the agricultural requirements of the country? and are the cattle dying faster than they breed?" but in the figures Sir Charles had given he started with the year just after the famine in Madras and Bombay, and, therefore, the large increase in the succeeding six years was mainly due to the reaction from that terrible mortality. It was estimated by a native journalist that on the average in India there was one pair of bullocks to 13 acres; in the North-West, 1 pair to 10 acres; in Bombay, 1 to 24 acres; and in the Southern part of the Deccan, only 1 to 32 acres. The same writer also referred to the opinion expressed by Sir James Caird, that 700,000 acres were lying idle for want of plough cattle. He found in the Indian papers an interesting report of an agricultural show in the Kholapur State, where the political officer, Colonel Woodhouse—who previously had seen much of similar exhibitions in the native States of Kattiawar—remarked on the insufficient attention given to the development of the simple agriculture of the country. In connection with that it appeared to him (Mr. Wood) that the introduction of better seeds would be a very practical means of improving the state of agriculture, and it could be done without any elaborate machinery or official interference. Mr. Robertson's remarks on irrigation had been admirably enforced by Sir Joseph Fayrer; and it was very necessary to insist upon its importance in season and out of season, for after all there was a good deal of misconception as to its relative importance. Sir Charles Bernard's remarks reflected not only the popular but the official view, that the extension of communications was of more importance than anything else. But though the surplus of one province might be taken to others, when drought came, by means of a railway, the general extension of irrigation in suitable forms would check the effects of drought, produce more food, and save the lives of both man and beast. The people in the deltas of the Godavery, and in Tanjore, when famine was raging all around them, were able to minister to the wants of their neighbours, and to reap a large profit from the dearness of grain. The same kind of irrigation could not be carried out everywhere, but for every province a suitable system might be devised. After all, they must remember that beyond and beneath all these obvious circumstances, there was one general economic cause affecting the state of Indian agriculture, and that was the want of means on the part of the ryot, which explained his helplessness. That was attributable, in great measure, to the economic condition of the country, which could not be altered without a combination of measures. This had been pointed out (amongst other economists) by Mr. Bagehot, who said that a country which sent abroad £15,000,000 worth of commodities more than it received must be placed in a very unfavourable position. Prices and profits were reduced in order to provide that excess of exports, and thus it was the ryot was obliged to dispose of every saleable article to meet his assessment. It was this fact which underlay the whole condition of agriculture in India, and was the main explanation of its ineffectiveness.

The CHAIRMAN said the remarks made by Sir Charles Bernard showed that the Government was not insensible to its obligations and its interests in regard to agriculture. The direct primary expenditure of nearly £30,000,000 sterling in 30 years on irrigation represented not capital only, but included large sums expended out of the yearly revenue; and with this sum not only had much been achieved, but much had also been done in preparing for the great works now being carried out, for instance in Madras, where the important Periya project was now under way. Much had also been done in developing those minor works to which Mr. Robertson rightly attributed such importance. The tank system of Madras and Mysore had been thoroughly surveyed by competent officers, and efforts had been made to induce the villages and districts to undertake the repair and completion of the local tank systems. Next to irrigation, in order to economise a scanty rainfall, the most important work the Government could undertake was admittedly the reafforesting of the country, and on that matter at least £800,000 was expended annually. It was gratifying to see that forest revenue showed an increasing profit, though he would be still better pleased if all the returns were reinvested in a further development of the system. When he was last in India, one of the chief forest officers in Madras informed him that if he were allowed to expend the surplus income which he earned, about 2 lacs of rupees a year, in a few years there would be a profit income from Madras of 50 lacs. That estimate might have been a sanguine one, but he was quite certain that the forest revenue might be greatly increased, and he looked to it to supply a source of revenue on which the Government would be able to rely in case of any failure in the receipts from opium. With regard to the expense of raising water from wells, though it was no doubt considerable still, at the time when it was required the plough cattle would not be employed for any other purpose, and the expense was not therefore really so great as it appeared. Economy in the use of water was very desirable, for, as Sir Joseph Fayrer had said, its undue employment caused unsanitary conditions. He thought it might be possible to introduce a method of charging by quantity, as in Italy, when the people would use no more than would be required to secure their crops. If that were done, not only would the same quantity of water suffice for a larger area, but the country would be healthier. Along many of the large canals, directly the water was introduced into them the level of the wells rose; the whole subsoil became flooded, and therefore whenever a canal was carried through such a soil, drains should be made to carry the water off again and deliver it at another point where it could be again utilised. With regard to the introduction of new staples, he might remark that the Government had introduced cinchona, and encouraged three others, tea, coffee, and jute, of which the total value exported reached £12,000,000 annually. With regard to wheat, it was remarked on the occasion of the reading of Mr. Robertson's previous paper, that a sudden diminution had occurred in the export at a time when it could not have been expected from the extent of the crop, and it was explained that it was consequent on a dearth of other food grains. It was a circumstance not altogether to be regretted, from an Indian point of view, that export was so readily affected that if India wanted more food she could get it by retaining the wheat in the country. Railways had two effects as regards famine. In the first place, they developed production. In 1877, there was in Upper India what was called a money famine; the people, living on the rain harvest of millet, generally sold the winter harvest to pay their assessment. In this year the harvest was so bountiful and prices went so low that a man could scarcely raise his revenue charge if he sold every grain of wheat he had grown; but at that time came a large demand from Madras, and many natives went into the grain trade, and withdrew the whole of the surplus crop from these congested districts. Later in the year, in the same districts, the monsoon, which ordinarily commenced in June, failed entirely, and there was no rain until October; consequently, at the period when the rain crop would ordinarily have been harvested, severe distress manifested itself, which was happily not of long duration and promptly met by imports. But if the wheat crop had not been thus carried of to South India, the cultivators, in future years, would not have grown so much; it was the fact that the railway could carry away their crops which led the people to increase their acreage under wheat, until now, according to figures recently issued from the office, the total area was 19,000,000 acres. Railways were also useful in supplying food to the famine districts, and anyone looking at the map of India to-day, and comparing it with one of twenty years ago, would see an immense difference in this respect. There were now three large railway systems by which food could be brought either to the south from the north or to the north from the south. He could not allow the statement to pass without qualification that the Government was the absolute landlord of a great portion of India; especially as on a former occasion a statement had been made with regard to the ryotwari tenure which was not quite accurate. It was held in Madras that the ryotwari occupier was not a mere tenant at will; that he had just as good a title as the zemindar, with this important difference, that he could in any year renounce a portion of his holding, which was a great advantage in a country so largely dependent on the rainfall. In the last report on agricultural matters in Madras he found a statement that owing to the plentiful rains of 1888-9 500,000 acres, or 2 per cent., had been added to the land under cultivation in a single year. It was very desirable to encourage the ryots to take up as much land as they could profitably cultivate when a favourable season justified the risks; but if they were obliged to hold it for a term of years it was clear they would not be so ready to do so, as if they incurred no liability beyond the first year. He could not agree with Mr. Robertson that the Government should interfere and place the ryot under conditions as to the crop he should grow. Rotation of crops was not unknown in India, and in some parts of the country he had known the holdings changed year by year, which could only be explained on the theory of a rotation of crops. He had known villages where the landlords gave their tenants a different piece of land each year. He did not think the Government could do more than to avoid legislation which would impede this exchange of lands, when it was carried out, because certain men exhibited a special talent for producing particular crops. He believed that the Kumbies and Kocries grew the greater part of the sugar and tobacco which was produced in Upper India. He quite agreed in the advantages of deeper ploughing, when the ryots had sufficient bullock power. Where there was no canal irrigation, a small boundary was erected on each side of the field, so as to pen up the rain when it fell, and compel it to soak into the ground; the surface then became baked, and beneath there was retained a small reservoir of moisture, from which the crop derived sustenance. The deeper the field was ploughed the more water sank in, and except in those cases where salts were brought up from below, the more water in reason brought or put on a piece of land the better. When he was last in Allahabad he saw land that had been thus treated, and in the midst of summer it was bearing a crop of grass. He had no reason to suppose that Indians were reluctant to use any kind of manure they could procure, except for caste reasons, and caste was dying out. As soon as the Hindoo found that it paid him to use manure, he would cease to export the thousands of tons of bones which were now leaving the country. But at present no one ground these bones for him, or mixed them with acids, or prepared them for use on the land, and he could not do these things himself. In the neighbourhood of Madras, ryots who cultivated rice put upon the land not merely leaves of trees, but the refuse from fellmongers' yards, and other waste products. One effect of railways was to induce the people to move about the country, and they would no longer remain in a place where there was no profitable scope for their industry; they would gradually give up soils which were becoming exhausted, and move to fresh lands. Seventy thousand coolies emigrated every year to Assam, the Straits Settlements, and to Burmah, and a large number to more distant lands, and in a short time it was reasonable to hope that the same kind of labour movement would take place in India itself. Why had India so few sheep? In the first place, because Indians were not meat eaters; and next, they preferred cotton to wool, and they therefore devoted themselves to other industries than sheep farming. It was not every part of India either that would carry sheep; but he was glad to say that a very valuable mixed breed of sheep had been established by Mr. Robertson in Madras. the quality of which, both as respects meat and fleece, was very superior to that of the country breeds. Mr. Robertson had expressed the opinion that it would be useful for the Government to insist that its officers should have received some education in agriculture. Now the Indian civilians of the higher grade, who only numbered about 1,000, required the quality ascribed to the Athenians by Pericles. They must be *entrapeloi*, men who could turn themselves easily to many kinds of business. They were required to preside over very large departments, and had not to devote themselves exclusively to any one branch of business. A collector was a magistrate, a revenue officer, a sanitary officer, and had many other functions. The Government desired to enlist the man of large mind and liberal education and put him in a sphere of duty where his interest in his work would lead him to make a special study of the interests of his district or his department. In no part of the world would you find officers who devoted more of their time, and in some cases, so much of their fortunes, to develop agriculture as did the superior revenue officers in India. He might mention Mr. Halsey, of Cawnpore, in whose school graduated Sir Edmund Buck, the present head of the Agricultural Department, and Mr. George Ricketts, formerly collector at Allahabad. In every district in the North-West, some collector had left behind him the marks of the interest he took in agriculture. Similarly in Madras, though some of the revenue officers did not take quite the same views as Mr. Robertson on all points, they were all interested in agriculture, and many of them had more than a mere superficial knowledge of it. A great deal was also being done to educate the subordinate officers connected with the land revenue. In each province an agricultural department had been established—the total expenditure being £40,000 a year—the first duty of which was to educate those who assessed and collected the revenue. When he first went to India one of the greatest hindrances to successful agriculture was the delay in concluding a settlement. Measurements and ascertainment of boundaries led to endless disputes, and it took three, four, or five years, and in some cases much longer, to complete the settlement, and during all that time the occupiers did not know at what rate they would be assessed. This led to great difficulties in borrowing money when required; he had known the revenue raised 250 per cent. on one piece of land, quite justly, but if any one had lent money upon it on the supposition that the increase would be only that general in the district the security must have been greatly impaired. The steps now being taken were intended to secure such a record that at any moment you could tell whether the assessment was too heavy, and what would be a reasonable demand, so that when a new settlement had to be made it could be done almost by agreement with the proprietary, and without disturbing titles. No one who had witnessed the success of the Agricultural College at Sidapet, under Mr. Robertson, would doubt its value; in the first place it extended the knowledge of agriculture; and in the next it afforded a career for a class of persons to whom few opportunities were open; the sons of the small landed proprietors. As a rule they did not care for clerical offices, and their chances of obtaining advancement in the public service were much impeded by the superior hereditary ability of the Brahmins; but they were particularly well fitted for revenue duties. Whilst in some parts the Hindus had largely ousted the Mohammedans from employment, in the North-West and the Punjab the Mohammedans more than held their own, because they had so largely filled the clerical offices. He regretted that the college in Madras had not been quite so successful under a less experienced principal than Mr. Robertson; but in time he hoped it would re-regain its high position, and in Dr. Cooke the Poonah College had a president who was eminently fitted for his position. A doubt had been expressed whether India was as prosperous as could be wished, looking at her exports and imports; but he denied than an unfavourable inference must necessarily be drawn from them. It produced £90,000,000 worth of goods which it was able to dispense with, for which it received goods, including bullion, which it could not produce, or could not produce at an equally remunerative cost. It also received services or capital which it could not at present itself furnish. In five years, however, imports increased by £12,500,000, while exports increased only by £7,000,000. The real reason why India was not equally prosperous every year was the same reason that Russia and France were not. It was an agricultural country, and its main industry depended on the seasons. At one time India exported sugar; but it now consumed, on an average, 26 lbs. per head, while France only consumed 27 lbs., and Austria only 9 lbs. In India, the consumption of sugar was almost as good a test of prosperity as the liquor trade in England, and it was now not only consuming its own produce, but importing sugar. Reports from all parts of India showed, speaking generally, a substantial improvement in the condition of the agricultural classes. The Indian wheat was not so clean as could be desired, partly because the ryot often cultivated mustard along with it, or some other grain, and partly because not having good barns, he had to winnow it on an open floor at a time when there were strong winds blowing which brought a good deal of dust. The last crop-testing of the Agricultural Department showed a production of 1,300 lbs. per acre in Assam of paddy for autumn rice, and 1,500 lbs for winter rice. In Bombay, wheat averaged from 600 lbs. to 900 lbs. per acre; paddy, 1,600 lbs.; and the sugar crops were estimated to be from 5,520 lbs. to 8,271 lbs. of coarse sugar per acre, or an average of 6,448 lbs., though he could hardly think these figures were accurate. To show the necessity for rotation, it was stated that in Assam you might expect from an acre of mustard 560 lbs. the first year, 475 the second, and 336 the third. He concluded by proposing a hearty vote of thanks to Mr. Robertson.

The vote of thanks having been carried,

Mr. ROBERTSON thanked the meeting for the reception the paper had received.

FOREIGN & COLONIAL SECTION.

Tuesday, March 18, 1890: HYDE CLARKE in the chair.

The paper read was on "Brazil," by JAMES W. WELLS, M.Inst.C.E., F.R.G.S.

The paper will be printed in next week's *Journal.*

FIFTEENTH ORDINARY MEETING.

Wednesday, March 19th, 1890; Sir FREDERICK ABEL, C.B., D.C.L., D Sc., F.R.S., Vice-President of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Barrett, George Wilson, 9, Albany-court-yard, Piccadilly, W.
Brounlie, Charles de Bels, Gothic-house, Lower-road, Richmond, Surrey.
Congdon, John, 135, New Bond-street, W.
Lanham, Robert, Forest-house, Chingford, Essex.
Lansbury, Henry John, Town-hall, Bromley, Kent.
Mayne, Charles, Shanghai, China.
Pepper, Joseph E., Clarence Iron and Steel Works, Leeds.
Roberts, Thomas, 13, Corve-street, Ludlow.
Smith, William Howard Seth, 46, Lincoln's-inn-fields, W.C.
Swan, Joseph George, Upsall-hall, near Middlesbrough.
Tolmie, Andrew Denny, 166, Buchanan-street, Glasgow.
Wilson, T. Hay, 10, St. Bride's-street, E.C., and Crawcrook, Chingford, Essex.
Worssam, Henry John, Wenlock-road, City-road, N.

The following candidates were balloted for and duly elected members of the Society:—

Dalby-Welch, Reginald, Broad-street-avenue, New Broad-street, E.C.
MacRitchie, James, Singapore, Straits Settlements.
Scales, George McArthur, Belvoir-house, Hornsey-lane, N.
Shelley, Joseph Ball, Southlands, Longton, Stoke-on-Trent, Staffordshire.

The paper read was—

THE BEARINGS OF GEOGRAPHY ON COMMERCE.

By J. SCOTT KELTIE.

I need hardly remind an audience like this of the important place which technical education has assumed in this country in recent years. We have, I hope, become alive to the fact that we have powerful competitors in the field of industry, commerce, and colonisation, and that we cannot afford to neglect any means that will enable us to maintain the supremacy in all these directions which has been ours for centuries. In commerce and in colonisation, as in so much else that is of this world, it is to be feared that the race is to the swift and the battle to the strong. But while, no doubt, breed or heredity counts for much, swiftness and strength come largely by training. Our neighbours on the Continent recognise this great fact so far as industry and commerce go, with the result that in all great European countries technical education holds a place of the first importance. In several respects we have by a long way the advantage of our neighbours; if, in respect of technical training, we see to it that those who will have the material welfare of the Empire in keeping are as well off as their rivals, I do not see why we should not retain the advantages we have inherited from our forefathers. But the struggle is getting keener and keener, and the sooner and the more thoroughly we adapt ourselves to the new conditions the better.

Every art, I am sure you will agree with me, is the application of some department of science. The Forth Bridge would have been impossible had it not been for a thorough knowledge of the laws of physics. Chemistry is applied in a vast variety of practical directions, but our Chairman will tell us that such applications imply first of all a knowledge of the great facts and principles of chemistry pure and simple; that the chemistry of explosives and the chemistry of dyeing are only special applications of these, and that you cannot go far in any practical direction unless you start with the science that underlies it. When geology is applied to mining it does not cease to be geology, and when chemistry and botany are enlisted in the service of agriculture, or electricity applied to electric lighting, they do not part with their scientific characteristics. If a chemist knows his chemistry, a geologist his geology, and a physicist his physics, the application of the knowledge in any particular direction need not be a matter of great difficulty. For thorough efficiency no doubt practical training should follow or accompany scientific instruction; but without the latter, fundamental progress is impossible. In short, for those who have the actual carrying out of the industrial and commercial work of the world, technical training and the old system of apprenticeship, or something equivalent to it, should go hand in hand. What has been the secret of the vast progress which the world has made during the last half century, if not the fresh discoveries made by the scientific investigator, and their applications to the wants of mankind?

Commerce involves a complicated series of operations. It may be said to be the final term to all industries; it is the great distributor of all the results of human activity, their realisation in pounds, shillings, and pence. Commercial efficiency, then, is surely a matter of prime importance to industries of every kind; and it is surely of moment that those who have the interests of our commerce in their keeping should not neglect any factor that may add to that efficiency. Is there, then, any sort of technical training that applies to commerce—any department of knowledge more than another that will be of service in its operations? It seems to me that geography, in the most comprehensive sense of that term, may be regarded as the department that more than any other underlies commerce, as distinct from petty trade. Commercial geography, in short, may be regarded as forming an important part of the technical training of the merchant. It occupies a place of the first rank in every commercial school on the Continent; it has received substantial recognition in the new programme of the London Chamber of Commerce; it is attracting attention in many directions, especially among examining bodies; we are being threatened with a flood of text-books and atlases dealing with the subject. It seems to me that very imperfect conceptions prevail as to what commercial geography really is, that is to say, what are the real bearings of geography on commerce, and how it may best be dealt with from the practical and educational points of view. We have had several text-books of commercial geography recently, but with probably only one exception they are not satisfactory. Some are purely statistical, others contain long lists of names of what are called products, scattered over a groundwork of thin geographical information; hardly one of them deals with fundamental facts and relations. Perhaps, then, I may most usefully occupy your time by attempting briefly to indicate what, in my conception, are the relations which subsist between geography and commerce, and how best it may be taught to different classes of pupils.

Before attempting to settle what commercial geography is, it may be advisable, first of all, to make up our minds as to the field of geography and the nature of commerce. As you are no doubt aware, some of the devotees of geography maintain that it is the science of sciences, that its sphere includes everything in the heavens above, the earth beneath, and the water under the earth. Without going so far as this, I think geography, even when confined to the surface of the earth, embraces a field quite wide enough for one department of knowledge. For a short definition you cannot get anything better than the old statement found in all text-books, that geography is a description of the earth. It all depends on what you mean by "description." You may approach geography from two directions. You can begin at the surface, and go downwards or inwards, and try to discover the causes of the great features which you find on the face of the earth—the oceans, and the continents, and the islands, the mountains and the plains, the lakes and the rivers, and all those other features which give such variety and beauty to the home of mankind. This is the scientific aspect of the subject; here you are seeking after causes. Or you may take these features as you find them—take into account the action upon them of all the influences to which they are subject—latitude and longitude, altitude above sea-level, of heat and cold; of wind, and rain, and drought; of distance from or nearness to the sea, with the varied covering of the surface, vegetable and animal, sand or rock; and of all those other factors which give a region character. You can study the relations of these factors to each other, and, above all, their influences on the kindly race of men who are planted in their midst, and whose lives and activities are to a great extent determined by them. On the surface of the earth you have land, you have water, you have the atmosphere, and over all you have the sun, the great source of all energy; and it is the result of the interaction of these great factors, combined with the earth's rotation, which to some extent makes the face of our globe what it is, and which has a marked influence on the welfare of human communities.

Geography is, indeed, the physical basis of all human activity. It is the thorough grasp of this aspect of the subject which, in the hands of Ritter, Peschel, and their followers has proved so increasingly fruitful of results in Germany. Readers of Buckle will remember the success with which, in many instances, he applies geography to an explanation of the development of civilisation; and readers of Green's "Making of England," will recognise the new light that brilliant work was able to throw on the course of the Teutonic invasion, by reproducing for us the geography of England of that period.

If, like Buckle and Green, we include in history not merely the growth of States and of their political institutions, but also their industrial, social, and intellectual development, then the paramount influence of geography becomes unmistakable. Buckle brings this out with his usual brilliancy, not only in the case of Egypt, but also of India, Central America, and Peru; and Green, both in his histories and in his "Short Geography of the British Islands," endeavours with much success to show how the growth of our industries and the situation of our great cities have been largely determined by conditions which are essentially geographical. Comte was not likely to overlook the intimate relations which subsist between geography and history in its widest sense. "It would be impossible," he wrote, "to conceive of any adequate history of humanity, apart from the real history of the terrestrial globe, the inevitable theatre of progressive human activity, and the various conditions of which must certainly have exercised an important influence on the production of the various phases of human history, from the period when the physical and chemical conditions of our planet were such as to permit the continuous existence of humanity."

It will thus be seen that the important results to be derived from the application of geography to history have been, in a general way, recognised even in this country. But the application has hitherto been altogether qualitative and not quantitative, and mainly because the subject has been approached from the historical and not the geographical standpoint. In Germany, where a voluminous literature is growing up as the fruit of the precise and detailed cultivation of the geographical field, some of the results attained, in their bearings on humanity, have been correspondingly precise, quantitative, and tangible. Not only are these results likely to prove of service to the historical student, but their bearings on industry, on commerce, on colonisation, are of the most intimate character. Commercial geography in Germany, for example, is something that the merchant and the merchant's clerk can take with him into his office and apply to his everyday transactions, and not the useless thing which goes under that name in our own so-called "commercial academies." Then the vast importance of the subject with reference to the recent colonial enterprise of Germany has been recognised by the publication of a multitude of books on what may be regarded as the economical geography of the various regions which have been brought within the German "sphere of influence." "Navigation and commerce," the German Emperor told the Brandenburgers the other day, "are the two greatest pillars of a State, on which its subjects depend for their very existence." England's geographical connections--political, colonial, commercial, missionary—are worldwide, and her politicians, her merchants and manufacturers, and all who are interested in the development of her colonies, could not but profit by a complete and precise knowledge of those conditions upon which the success of their operations so largely depends.

Geography, then, may be described as that department of knowledge which treats of the topographical distribution of the great features of the earth's surface, and all that it sustains, of their relations to each other, and above all of their relations to the greatest factor on that surface—man himself. If we bear in mind that as geographers, it is distribution and not constitution, groups or communities and not individuals, we have to do with, we shall be able to limit our field within reasonable compass. What is political geography—so barren and uninteresting in the text-book—but the department which deals with the distribution of men into communities? While commercial geography—the science of distances, as a German writer calls it—investigates the distribution (in a double sense) of the economical commodities over the earth's surface, and of the various industries connected therewith.

Commerce, in its larger sense, is essentially the transference or conveyance of commodities from one part of the earth's surface to another; from the place where they are found or manufactured to the place where they are wanted, *i.e.*, to their market. But the mere cataloguing of commercial commodities according to their place of origin, and according to their markets, would be a dreary task of almost no educational value; yet this is the conception of commercial geography you find worked out in some of the text-books. Commerce, in accordance with the definition we have given, implies the finding of your commodities to begin with; a knowledge of the conditions under which they exist or are manufactured; of the circumstances under which they are to be obtained; of the facilities and hindrances for taking them from where they are to where they are wanted, *i.e.*, to market, and of the character of that market and the conditions under which the commodities are to be disposed of there. Commerce, thus to be progressive, must be constantly on the outlook for new sources of supply, and for new fields in which to dispose of her commodities. Now much of all this, I think it is evident, is clearly connected with the kind of knowledge which geography in its broad sense ought to be able to furnish, and also with the kind of enterprise which we call exploration. You may think that geography cannot be of much help to the merchant who deals with highly civilised and thoroughly-known countries like Germany, France, Holland, and Belgium. But we maintain that the political, social, and economical conditions which prevail in those countries, the characteristics of the people, the conditions under which commerce must be conducted, are largely the outcome of the influence of geographical environment on man, and of man's action in modifying his surroundings. What are railways, canals, and telegraphs, but successful attempts to overcome topographical disadvantages and to lessen distances, and these surely are geographical factors. But whether we call it geography or not, our consuls abroad are continually telling us that ignorance of a country, ignorance of its people and their peculiar ways, ignorance of their language, ignorance of the wants peculiar to the country, is constantly placing our traders at a disadvantage, compared with the well-informed traders of an enterprising country like Germany, in the commercial schools of which geography holds so important a place. Under whatever heading it may come, it is surely in the interests of British commerce then, that such ignorance on the part of our mercantile men should not exist.

Let us look a little more closely into the great factors with which geography deals, and see whether, after all, the best foundation for a special training in the commercial aspect of the subject is not a thorough study of geography itself, taking it in the wide sense indicated already; whether applied geography, like applied chemistry, does not necessarily demand, first of all, an acquaintance with the subject that is to be applied. When you reflect for a moment how very large a proportion of the commodities with which commerce deals are obtained directly from the surface of the earth, are, in fact, vegetable products, how much of the remainder are directly or indirectly influenced by surface conditions, it must seem patent that a knowledge of these conditions ought to be of service to those who desire to conduct their commerce with intelligence. I need only remind you of such articles as cereals, cotton, and timber as direct surface products; of animal products (such as wool) as directly dependent on surface conditions; and minerals as more or less directly dependent for their exploitation on similar conditions.

Well, then, what are some of these conditions, so far as geography has to do with them, and which ought to be thoroughly mastered as the basis of commercial geography?

We have, first, the two notable divisions of land and water in all their varied forms. The relations of the two are often of the greatest commercial import. Take, for example, the outlines of the masses of land. Compare the monotonous contour of the African continent with the broken outlines of the other continents. See how Europe is everywhere penetrated by great arms of the sea, by gulfs and bays, and fjords and estuaries, affording magnificent harbourage, and giving access to the heart of the continent. Such is, to a greater or less degree, the case with the other continents whose commercial development has reached a substantial stage. Even Australia has its Spencer Gulf, its Port Philip, its Sydney Harbour, its Gulf of Carpentaria; though in the matter of openings into the land it is too like Africa, and had it been situated in the same latitude it must have been as far behind to-day as the Dark Continent.

For latitude is one of the most important geographical factors, and one having the closest bearings on the interests of commerce. Take, for example, Africa, the worst off of all the continents. If you look at the map, you will see that two-thirds of its surface lies within the torrid zone. Now, it is not only that that two-thirds is difficult of access to any enterprises conducted by Europeans, but this enormous surface is, like a great furnace, spreading its torrid influences north and south. Europe and Asia are within the temperate zone, except a bit of Arabia, India, and the Indo-Chinese Peninsula, and those northern regions which stretch into the inhospitable circle of the frozen ocean. But that is only a small proportion of the great Euro-Asiatic land-mass. So, too, with North America; the great mass of the mainland is within the temperate zone, as is a large section of South America and more than one-half of Australia. Had it not been for its latitude, Africa would have been overrun by European colonisation and European commerce long ago. If you look at South America, you will see the difference which latitude makes to industrial development. North of the tropic of Capricorn lies most of Brazil, Peru, Bolivia, Venezuela, Columbia, Ecuador, Central America, where revolutions are chronic, where northern Europeans cannot labour, where the climate is inimical to exertion, and where everything is stagnant. South of that tropic we have the Argentine and Chile, two most enterprising nations, who have done well in the past, and who have a great future before them. But there are certain circumstances which modify the natural effect of latitude. There is the influence of the ocean itself, which acts as a powerful moderator. Contrast the mild winter of the British Isles and Western Europe with the rigorous winter of the interior of the continent, even in more southerly latitudes. This factor is itself subject to variations, dependent to a large extent on the direction and temperature of its surface currents, and these again owe their origin to a large extent to the prevailing winds. The Gulf Stream is a well-known example; there can be little doubt that it has some effect in producing the mild winter climate of our islands, a marked contrast to the vigorous winter climate of New York, more than 10 degrees (700 miles) south of London, due largely, no doubt, to the cold current that comes south from Labrador. On the opposite coast of America, from New York, they have at Vancouver Island and British Columbia, in our own latitude, the same open climate that we have, due largely to a warm current similar to the Gulf Stream—the Japan current, or Kuro Siwo. It is partly due to this, and partly, no doubt, to other causes, that what is known as the mean annual isotherm of 40° Fahrenheit sweeps north-west from the mouth of the St. Lawrence to Alaska. That is to say, the western parts of the Dominion of Canada, which are in the same latitude as inhospitable Labrador, have the same temperature as the country at the mouth of the St. Lawrence, a most important fact for industry and commerce, seeing that it renders possible stock-rearing and agriculture on a great scale in one of our most important colonies, and keeps the harbours open nearly all the year over.

There is still another point that must be taken into consideration in the interests of commerce as tending to moderate climate, and that is, altitude or height above sea-level. The configuration of the land surface of the globe is one of the fundamental elements with which geography deals. We have mountains assuming many varieties of aspect — long ranges, such as we find up and down the coast of America, along the northern border of India, and crossing Central Asia, great masses like the Alps, isolated groups and peaks like Kilimanjaro, and Mr. Stanley's Ruwenzori; and then we have those worn-down mountains which we call table-lands. Mere altitude has such a modifying effect that even in South Europe, in Switzerland, North Italy, France, and Spain, human life and human activity cannot be carried on above a certain moderate limit; whereas at Quito, just on the Equator, you may have an elevation perfectly tolerable to Europeans, for it is 9,520 feet above the sea. As a rule, for every 300 feet you rise above sea-level, the air grows cooler by one degree Fahrenheit; so at 3,000 feet above sea-level you get it 10° cooler, and 5,000 feet nearly 20° cooler than it is at sea-level. This is a most important fact for the development, under white men, of tropical countries like Central Africa.

Here we have got into the subject of climate—a critical one, I need not remind you, with reference to the transactions of commerce. Latitude, altitude, the relation of the land to the ocean, are all elements which help to form climate. But, above all, the direction from which the wind comes as a whole is of prime importance, for that, again, governs to a great extent the rainfall; and the amount of rain that falls on a country, as you know, determines its fertility, and its suitability for a great variety of industrial operations. Take the great Sahara, or the Kalahari, or the Gobi Desert, or the great desert tract in the United States to the east of the Rockies. They are barren, simply because they get little or no rain; and they get no rain, either because the wind does not come from the right direction, *i.e.*, over the broad ocean, or, if it does, all the moisture it has sucked up from the ocean has been tapped by the coast mountains. It is possible to have too much rain; our average is about 25 inches a year. In the dripping forest through which Stanley passed to the rescue of Emin, it is about 75 inches; in some parts of the Eastern Himalayas it is as high as 800 inches.

This question of climate, and especially of rainfall, is of vast importance with reference to our own colonial empire. Thus, in India, the density of population in many places is in exact proportion to the rainfall. In Australia you have belts extending from the coast inland, where the rainfall decreases in regular gradation, from over 75 inches a year to almost *nil*. Now the agricultural and pastoral capacity of the country corresponds precisely to its rainfall. Thus for every inch over absolute drought you can graze one sheep per square mile, though the ratio goes on increasing. You can have 22 per sheep per square mile for every inch of rain over nine inches. In New South Wales, 20 inches per annum gives you feeding ground for 640 sheep per square mile, *i.e.*, one per acre, and even that cannot be considered very high, and could only pay in a country where land is plentiful and cheap. Or take wheat in South Australia, one of the great wheat-exporting countries. You know that the yield of wheat is measured by so many bushels per acre. In this country, for example, you may get 26 to 30 or more bushels per acre. In South Australia, with 18½ inches of rain a year, the wheat harvest yields 12½ bushels per acre; 15 inches of rain yields 10 bushels; 13½ inches yields only 6½ bushels. An extra inch of rain in the season, it has been calculated, on the total wheat area of South Australia—some 2,000,000 acres—would give it an additional fee-simple value of £10,000,000, if wheat at 4s. a bushel, or equivalent crops, were grown. In Melbourne, recently, the people of Victoria have been attempting to manufacture their own wool into cloth, and so avoid the necessity of importing so largely from England. Fortunately for us, the climate is so dry that, to begin with, they cannot succeed in making yarn that can at all compare with that made in Yorkshire. A certain amount of moisture, it seems, is required to turn out satisfactory yarn, which is found in the atmosphere around Bradford and other manufacturing centres, which is not found in Australia. So I am told is the case also with the manufacture of cotton yarn, which is the great staple in Lancashire; though the fact of that being the great centre of cotton manufacture in this country is no doubt due, to a large extent, to the geographical position of Liverpool, which makes it the great port for the import of raw cotton from the United States.

I adduce these facts to show how very important a factor rainfall is in judging of the commercial value of a country. But for its scanty rainfall the Sahara might be as rich a country as the central United States. The lack of rainfall in our Cape Colony is one of its great drawbacks.

Nothing is more influenced by climate than the vegetable covering of the face of the earth, and how important that is from a commercial point of view may be seen from the fact that half our imports—*i.e.*, nearly £200,000,000 sterling—are of vegetable origin, and over one-third of our exports are manufactured goods of vegetable origin; I need only mention the import of raw cotton and the export of cotton goods.

The distribution of forests over the globe means the possibility of timber supply; and there are other natural vegetable products, like India-rubber, ebony, fine woods like mahogany, oil-nuts, and so on, which are of importance to commerce. But of much greater importance are the cultivated plants. Take for example wheat; the laws which govern its distribution, the geographical conditions under which, in its many varieties, it may be grown with advantage, are well known. Temperature, rainfall, and soil are the important factors. So with other cereals, barley, oats, maize, rice; so with tea, coffee, tobacco, cotton, the vine, indigo, the olive, and other cultures of commercial value; these articles are all regulated in their distribution by the various factors to which I have referred; and, with proper geographical data, we ought to be able to say with respect to new lands, for which of these, if any, they are suited.

Wild animals are of less importance than wild plants to commerce, though indirectly their abundance and character may seriously affect the commercial value of a country. Take ivory: that is now one of the most important exports of Central Africa, yet probably it does not represent more than a million sterling annually, less than the export of wool from the Cape alone. As a rule, the mere natural animal and vegetable products of a country can never be of the first commercial value; far more important is it to know for what artificial cultures and what domestic animals any country is adapted.

It is different with minerals, which form natural products which may be the making of a country. Our own coal and our iron have combined with our advantageous geographical position, and the contour of our islands, to give us a start in the political and commercial race of the world, which it is only to be hoped we may not lose through ignorance. Precise knowledge of the distribution of the more important minerals no one undervalues. But the more detailed our knowledge of the geographical conditions amid which they exist, the more shall we be able to realise their commercial value. There may be abundance of gold and iron and coal in localities which are practically inaccessible, or where the communications are so defective that it would never pay to work the minerals. There is plenty of gold in the interior of the Gold Coast, but the climate is deadly. Almost equally deadly is it to collect the gold which is running in the low-lying rivers of Mashonaland. On the other hand there are no doubt plenty of reefs that may be worked without injury to health, but these reefs may be so out-of-the-way, may be so difficult to reach with the necessary stamping machinery, that to work them would be ruinous. Hence the great importance of that special branch of commercial geography which deals with communications and trade-routes. You get your commodities, you overcome all local difficulties, and it remains for you to get them taken to their destination. What sort of a country have you to pass through? What are the means of conveyance? Must the articles be carried on men's heads, or on camels as in Africa, or on llamas as in the Andes, or on mules or horses, drays or canal boats, on railways or on ships, or on all of them? One of the great aims of modern commerce is the shortening of distances by laying down railways, cutting through isthmuses, increasing the speed of our steamers. The importance of railways I need not point out. One of the most striking examples is the railway recently completed between the Caspian and Samarcand, in Central Asia, which threatens to divert the whole of the trade of that vast region from India to Russia. Just the other day, in a long communication in the *Times* (written, I believe, by a young and rising Member of Parliament), much was said on this subject; and, as a counterstep, it was advocated that we ought to run a railway from India up through Afghanistan, so as to draw at least a portion of the trade into our hands. In a later communication by the same writer, the importance of railways in modifying and improving geographical conditions is forcibly illustrated. After describing the mode of travelling in Persia, and the enormous time it takes to get over the ground, he says that, after riding through Persia the visitor carries away two impressions—first, that the country is a land of mountains; and, second, that the population falls far short of what, under better government, and more scientific administration of the water supply and cultivation of the soil, it might be. The orography of the country will explain a good deal that is peculiar in its history, and is largely accountable for its backward condition at present. Old customs and prejudices are harder to break down in a land so split up and sundered, civilisation and commerce more difficult to introduce. What a revolution railways would effect in that country the stranger does not require to be a month in Persia to find out.

To take an instance from South Africa. A railway goes from the Cape up to Kimberley, some 500 miles. You can take quartz-crushing mills all the way for a very moderate sum per ton; before your cargo reaches its destination, not many miles further on, it will cost ten times the same amount per ton to be carried on ox-waggons. The construction of the railway through the heart of Canada, from the Atlantic to the Pacific, has enormously increased the commercial value of the Dominion. The construction of railways has turned India into one of the great wheat-exporting countries of the world.

When once you get your commodities to the coast, then comes the question of the nearest convenient port, and at the other end, the most suitable point to land them. Several other factors come into play in considering the various conveniences and hindrances for the transfer of commercial commodities over the globe; factors like the risks of navigation, various port charges, and especially customs' duties or tariffs, which are so enormous in some countries as to be almost prohibitive of commercial intercourse. The importance of the post and telegraph as diminishers of distance, and therefore as handmaids of commerce, I need not insist upon.

But the prime factor of all, in studying the surface of the earth, the greatest feature on that surface is man himself. Had a different type of men from the Chinese—men with good bridges to their noses, like ourselves—possessed that vast territory, how different would the results have been! The land would have been honeycombed with coalpits; though great reefs of the coal are said to crop out on the surface in some places. It is the influence of geographical conditions on man, and his action upon them, that lie at the very foundation of commerce, and of every other manifestation of human activity. It is, therefore, of prime importance, from an industrial point of view, to know thoroughly the character of the people who inhabit the various regions of the earth. Thus, in Central Africa, white people cannot do the hard work; if, then, you cannot get the native African to labour, what comes of your commerce? Even in countries like Spain and China, and India, traders often make the most fatal blunders through the ignorance of the people and their ways. Foreigners get the better of us, because they take the trouble to be able to address the people in their own language. Ignorance, or inattention to the peculiar religions, or superstitions, or customs of a people, especially in uncivilised or semi-civilised countries, may ruin commercial enterprise; we have had recent examples in Africa.

Such are some of the geographical data that have a direct and important bearing on commercial enterprise. You have the various physical conditions to which I have referred; and you have man in the midst of all. These are the two great factors of every form of human activity. In seeking for your commercial commodities, you are bound to take them into account, as you must do in seeking after your market. The better you know them, the more successful you are likely to be; and, moreover, the thorough study of them is a matter of great intellectual interest.

What we may call the commercial or statistical expression of the results of the interaction between man and his geographical surroundings, may be made to arise out of the data which I have suggested very naturally and instructively. As I have already said, too frequently what passes as commercial geography consists solely of such statistical information without any attempt to show its relation to the geographical factors of which it is an outcome. No doubt such statistics are useful in their own way, but by themselves they are not commercial geography. From an educational point of view, I cannot think they are of any real value, unless shown to be a natural outcome of a certain set of geographical conditions. On the other hand, obtain a thorough grasp of all the geographical data that bear on commercial production, and they can be applied anywhere in old countries and new, and a conclusion arrived at as to whether the statistical results are adequate, or what, in the case of a new country, these results ought to be. Let me illustrate my meaning by a brief reference to Africa, which may be done with the aid of the special maps which are before you. These and the other maps which are hung on the walls I bring before you, not for the purpose of giving you a lecture on the commercial geography of the world but to show what, in my estimation, are the kind of maps most useful in connection with the subject. In its advanced stages, especially, the general maps should be on as large a scale as possible, and alongside of them ought to be a series of simple special maps, each of which shows only one factor in distribution. In this way the various factors can be easily compared—the orography, the rainfall, the population, the natural and cultivated products, and so on—and any relations which may subsist between them clearly brought out.

With regard to Africa, note first the position which she holds with relation to the rest of the world. She has the broad Atlantic stretching away out from her west coast. Her south coast looks down upon the eternal ice that envelopes the antarctic region, but, fortunately, a long way off. The warm water of the Indian Ocean bathes her shores on the south-east, while on the north-east and the north she has the great mass of the Euro-Asiatic Continent, with only the narrow strip of the Red Sea, and the somewhat wider Mediterranean between. Now, if the winds and ocean currents are favourable, and the contours of the land analogous to these of some other continents, Africa should, on the whole, be well off. So far as the centre of the continent goes, it fares not badly. The winds that blow across the Atlantic on the one side and from the Indian Ocean on the other, bring with them a reasonable amount of moisture. There is a comparatively cold ocean current, known as the Benguella current, that runs from below the Cape up the west coast to beyond the mouth of the Congo, which, no doubt, tends to diminish the rain supply from this quarter. But all round the Gulf of Guinea there is a warm current, and a general inflow of moisture-laden winds towards the land. On the south-east coast, again, we have a warm ocean current, the Mozambique current, running south, and a general tendency of the winds to blow towards the coast. Further north, towards the Horn of Africa, as it is called, we have in summer the moisture-laden monsoons carrying a rich tribute of rain towards the land, with little or nothing to hinder its deposition. When, however, we go north of that, north, say, of about 22° north latitude, we find the geographical position not by any means favourable to commerce and industry. There we are in the region of the Sahara, covering some 3,000,000 square miles, between the Nile Valley on the east, the Atlantic on the west, the Mediterranean Sea on the north, and the fringe of the Central Soudan States on the south. Although the Atlantic bathes all the west coast of this region, unfortunately the winds, instead of blowing towards it, blow away from it. What are known as the north-east trade winds (owing to their importance to navigation), just skirt the coast and do it little good. True, the prevailing winds of the year on the north and north-east come across the Mediterranean and Red Sea, but they have just passed over the great land masses of Europe and Asia, and parted with most of their moisture to these favoured continents, and the little they can pick up from the narrow seas is deposited on the coast, and almost none reaches the Sahara.

Now let us consider the contours of configuration of the land itself, and see how far these are favourable to commercial enterprise, and see to what extent they are likely to modify, or profit by the surrounding conditions to which I have referred. One of the maps before you is contoured to show the leading elevations of the continent above the sea. You will see that the greater part of the surface of Africa is what is called a plateau or table-land, of from 3,000 to 5,000 feet above sea-level. Over nearly all the coast region you have a low strip of less than 1,000 feet, rising rapidly in terraces to the general height of from 3,000 to 5,000 feet, which prevails over the greater part of the continent. In Northern Africa, over most of the Sahara, the general limit is lowered to 2,000 feet, and on the west and some patches in the north to less than 1,000 feet, and even in a few spots below sea-level. On the east coast the low strip is often quite 100 miles wide, while, of course, the valleys of the great rivers are all on a low level. But the configuration of the surface of Africa is, on the whole, that of a plateau of from 3,000 to 5,000 feet above the sea-level, dropping down on the coast by irregular terraces. Look at the map, and you will see scattered over the surface some darker patches. These patches indicate the only parts of Africa that rise over 5,000 feet. You will see how few, and scattered, and isolated they are, compared with the whole extent of the continent, and how different Africa is in this respect from any other continent, except Australia, with which it has a good deal in common, making allowance for difference of latitude.

You may ask what all this has to do with commercial geography. It has a vast deal to do with the industrial development of Africa, and without the possibility of such development, the occupation of commerce is gone. These mountain ranges are the great moisture catchers. When the southern monsoons sweep northward over the Indian Ocean in the summer, they throw themselves against the cool Himalayas and part with their moisture to such an extent that, in some places, the rainfall in India reaches 800 inches a year. Thus the configuration of a country has much to do with its rainfall, and on its rainfall the value of its commerce largely depends. In Africa there are no great coast or even inland ranges to cool the moisture-laden air that would pour over them. If you look over the rainfall map you will see that scarcely a drop falls over the whole of Sahara; the northern slopes of the Atlas catch what the winds from the north can bring with them. At Alexandria, about eight inches fall in the year, but by the time the wind gets to Cairo, it hasn't a drop to spare; there, scarcely an inch falls in the year. Over much of the Sahara the rainfall is almost *nil*; nowhere above 10 inches; in a region where the heat is so intense and the evaporation so enormous this is of no avail. Beyond the tropic of Cancer it begins to increase, and a wide belt here has from 10 to 25 inches, a scanty supply for the tropics. Still further south again, at about 10° north, over the Central Soudan States, we have from 25 to 50 inches, and this is just enough to give the inhabitants hope of their labour, if they till the ground and store the water for irrigation purposes. In a fairly broad belt, extending to 10° north of the Equator, and not quite so much on the south, we get into the region of fairly abundant rainfall, say from 75 inches to about 100 inches, for hardly anywhere in Africa does the rainfall reach beyond that. On the south again, and especially towards the south-east, the rainfall graduates off. From the mouth of the Congo in a broadening belt to the east coast, down the coast of Natal to about Port Elizabeth, the rainfall is fairly abundant, but west of that we have sterile regions like the Kalahari desert, Damaraland, and Namaqualand, which are little better than the Sahara, and in the interior parts of Cape Colony the annual rainfall in many places is not more than 10 inches.

There is one other element which must be taken into account. Of the 11,000,000 square miles, something like 8,000,000 have the sun vertical twice a year; and there the average annual temperature is over 80°, and in a large central area over 85°. Take it all in all, Africa is the hottest continent on the globe. But when we speak of these averages, 80°, 70°, 60°, and so on, we mean the average at the level of the sea. Now here comes in one advantage of the prevailing plateau character of the bulk of the continent rising 2,000 to 6,000 feet above sea-level. Thus it comes about that in the interior, in spite of the want of the cool sea breeze, the climate may be cooler than at the coast; so cold, indeed, sometimes, at night that you want a blanket and a fire to keep you warm.

Now, keeping in mind the distribution of rainfall, the distribution of the sun's heat, the prevailing plateau character of the continent, let us see what are the results as to the productiveness of the soil, as to the habitability of the continent, and as to its capacity for colonisation; in short, what is its commercial value? Compare the map which illustrates the great distributions of the soil with those that show distribution of altitude, of rainfall, and heat; you cannot fail to note a very marked correspondence. Take, first, the rainless region of the Sahara, with its almost entire absence of vegetation, its enormous stretch of sand dunes, and sandy plateaus strewn here with sharp stone and there with pebbles. The desert encroaches upon all the countries on its north, Morocco, Algeria, Tunis, Tripoli; but in these countries on the northern slopes of the hills, in the valleys between the ranges, and in the lowlands on the Mediterranean, various cultivations flourish—wheat, maize, tobacco, and the vine. Magnificent grapes are produced in Morocco, and under proper guidance it might be made one of the great wine-producing countries of the world. On the east of the Sahara we come to the great valley of the Nile, that once mysterious river, whose yearly overflowings make it possible for a dense population to live on its banks. But the strip of fertile land is narrow, and between the Nile and the Red Sea the country is mainly desert. Still the Sahara is not entirely without commercial interest, for on its oases grow those date palms the fruit of which form an article of export.

Coming south, when we reach the twentieth degree of north latitude, where we meet with our first belt of rain, we enter upon a region where the grass begins to grow, and as we go south it gets more luxurious and more permanent, and the trees appear in greater numbers. Just about Lake Chad we enter one of the most interesting regions of Central Africa, from a commercial point of view. Here we are in what is known as the Central Soudan, and here the rain falls in fairly useful quantity. Sokoto, Gando, Wadai, Darfur, Kordofan, though they have their dry and barren areas, form, on the whole, a fine and fairly well-watered region, with abundance of grass and wood, yielding forage for flocks and herds. Between the Niger and the Nile these States cover about 700,000 square miles. West of the lower Niger, again, between that and the Gold Coast, we have even a better watered, and, therefore, a richer region, so far as the produce of the soil goes.

South of these States we enter upon the great tropical forest of Africa, which gets denser and denser as we come south towards the Aruwimi tributary of the Congo, that covers most of the Congo river, from Lake Albert Nyanza and Tanganyika to the coast, and which, with its fringes north and south, may cover another 800,000 square miles. That forest, you will see, coincides with the region of greatest rainfall. East of it and south-east of it, after crossing Lake Albert and Lake Tanganyika, you come almost suddenly into a totally different country, marked, I believe, though it is not shown on the map, by a lower rainfall. Here there are in general plenty of trees, but scattered about in clumps, as in our English parks, though sometimes closing up into a forest character, while the grass is most luxuriant. But in this eastern half of tropical Africa, extending from the north of Mount Kenia south to Lake Nyassa, there are enormous areas of barren or desert lands, in which scarcely a stream is to be met with, and where the explorer or trader may have to travel two or three days without coming to water. As you approach the Zambesi, water becomes more plentiful, and grass and trees abound; and in the country around Lake Bangweolo (where poor Livingstone died), and to the west, where the Zambesi and several of the feeders of the Congo rise, the country is a great sponge—you can hardly get out of water.

In the eastern section we have Matabeleland and Mashonaland, and just north of that, on the other side, Nyassaland, about which we have heard so much recently. This, on the whole, is a fine region, capable of great development so far as its soil is concerned. Mashonaland, on the north-east of Matabeleland, a plateau of from 3,000 feet to 5,000 feet covering thousands of square miles, covered with a network of streams, and abounding in vegetation, is one of the finest regions in all Africa.

But then we come to that southern Sahara, the Kalahari desert, which is continued into Namaqualand and Damaraland right on to the west coast. You will see how all this corresponds with the rainless region of the south-west.

Take it all in all, then, I think it is not too much to say that some 4,000,000 square miles, more than one-third of Africa, is undoubted desert, while another million, I should say, is just beyond the desert stage, and could not be made anything of for planting and agricultural purposes without irrigation. Even in Africa, south of the Zambesi, you may have long rainless periods which turn much of the country into desert. Altogether, except a few patches on the central zone, there is only about one-half of Africa over which Nature is spontaneously exuberant.

There is another factor which I have only just alluded to. We have spoken of the supply of moisture from above, let us see now how the supply on the surface is distributed. Here, again, we find almost everything gathered into the great central region. All the great lakes of Africa are situated within the tropics, and all the great rivers either flow within that area or originate there.

Thus, you see how nearly all the natural riches of the surface of Africa are gathered into this central belt.

Now take the factor of population as shown on one of the special maps, and note the relation between its distribution and the distribution of rainfall. And, again, the distribution of religions, often a most important matter in commercial transactions. Further inquiry would show us that the great bulk of the central region is occupied by barbarous tribes, who have only reached the lowest stage of civilisation, and do little or nothing to develop the natural resources of the continent, or to cultivate the soil. On the northern and southern fringes of the continent we have white settlers and industrious native populations, differing in many ways from the peoples of the central zone. It is only these northern and southern fringes that can ever be colonised by Europeans; the great central region must ever harbour a native population, controlled it may be by whites, but with a labour question constantly cropping up to hinder progress. Then, again, we have few harbours and scarcely any inlets. The plateau nature of the surface breaks up all the rivers as they make their way down from the interior, so that natural internal communications are far from plentiful.

What, then, are the commercial results of this geographical condition of things in a continent that has been known to civilisation from time immemorial. I estimate the total value of the whole trade of Africa, imports and exports, at £85,000,000 (£20,000,000 less than Australia). Of this, the great central area, with all its native exuberance, yields barely £15,000,000 sterling, an area covering about two-thirds of the continent. The total exports of West Central Africa do not exceed £5,000,000, while those of East Central Africa, including the Portuguese colonies and Abyssinia, yield little more than £3,000,000. Of the £85,000,000, £40,000,000 must be credited to the Mediterranean countries, whose northern aspects are well watered, where active industries are carried on, and where the natural products (except minerals) are of small account. Other £30,000,000 go to the Cape, Natal, and other South African States, where also the only natural product of value are minerals.

This, then, is the measure of the commercial value of Africa, a measure that pretty accurately corresponds with the varied geographical conditions which we find to prevail over the continent. I have only been able to treat the example in the most summary fashion here; had I had time to enter into details, the lesson might have been still more striking. One conclusion, and it is an important one for commerce, is, that the mere native animal and vegetable products of a country can never become of much commercial value. The trade of the Nile Valley, only 13,000 square miles, amounts to £5,000,000 more than that of Central Africa.

My object so far has been to try to show what in my conception are the practical bearings of geography on commerce, what, in short, commercial geography is, and I have sought to illustrate my ideas by one or two examples. Briefly, in conclusion, may I say a few words as to whom the subject should be taught, and what are the best methods of teaching it. When we regard commercial geography as essentially one of the practical applications of geographical knowledge, it seems to me that such practical application can be introduced at any stage. I am no advocate of primers of commercial geography; by the time the pupil is ready to take up the subject as a special branch of technical education he has no time to trifle with primers; he must throw himself into the subject in as great detail as practicable. Only in this way can it become of practical utility in the actual operations of commerce. But even in the Board school, during the ordinary geography lesson, any teacher who knows his subject and knows his business ought to be able to indicate simply, as he goes on, the practical bearings of the facts with which he deals. Take our Colonies for example, which ought to form the most important section of the geography taught in English Board schools, might it not be possible to indicate the industrial and commercial bearings of their geography; the significance of the facts dealt with in regard to the suitability of a colony and its various subdivisions for colonising purposes? Take the data already adduced for example, with reference to Australia and Africa; how many grievous mistakes might be avoided if emigrants knew exactly the geography of the colony they were going to, and their economic significance. A hint dropped by a teacher during the course of an ordinary lesson could hardly fail to impress the young mind, and might prove of lifelong value. In more advanced schools and classes, the same method might be followed in greater detail, and in all cases as far as possible with the aid of special maps, photographs, pictures, and even specimens of products. I have seen this method followed with success in a Birmingham Board school, where, among other things, the teacher had collected specimens of the various kinds of wheat cultivated in the great wheat-growing countries. In the most advanced stage, when the subject becomes a special one, and the pupils are young men qualifying for a commercial or industrial career, it may be to assume a leading position in the development of one of our colonies, or of a new region in Africa or elsewhere, it seems to me the ideal plan would be to follow in minute detail the method just indicated. The basis should always be a solid knowledge of geography, to be worked out logically and precisely into commercial and industrial results and statistics. Look the facts of geography boldly and inquisitively in the face, and their commercial significance cannot but suggest itself. Such a method, it seems to me, is much more fruitful than if you take these results by themselves, and array them before the pupil as unrelated factors. Starting thus with a sound foundation, you can work out with intelligence in all directions. You can investigate the natural capacities and resources of a country; its agricultural capabilities; its communications, existing or possible; its suitability for colonisation, for the establishment of manufacturing industries; how far native labour can be depended on, and to what extent labour might have to be imported. All these and many other matters—all facilities and all hindrances to commercial operations—should be worked out in as minute detail as is possible, so far as these are directly and indirectly connected with geography. As you narrow the sphere of investigation, as you come down from the world to the continents, from continents to countries or limited regions, from these down to their subdivisions, you enter into greater and greater detail. The larger and more precise your maps are the better, for special maps are indispensable—maps such as these shown here to-night, each exhibiting only one feature, with the best complete maps available alongside. Whatever aspect of commercial geography can be illustrated by a map should be so embodied; and if pictures and photographs will help the student to obtain a better grasp of the commercial character of a region, then by all means employ them. I need hardly say that well-selected specimens of the products of a country, in their various stages, ought to be available, with statistical or other diagrams, clear and simple, to exhibit quantitative results. This is all the more important when you come to work out the commercial geography of particular commodities, such as wheat and other cereals, coal, iron, gold, and other minerals, cotton, wool, cattle, and so on. For in a complete course of commercial geography the subject ought to be approached from both directions; first, from the geographical basis, working outwards to products; and secondly, taking up each product and working out its geographical distribution, actual and possible, and all the conditions, down to routes, tariffs, harbour charges, and other minutiæ that affect commercial operations.

I by no means maintain that geography is everything in a commercial education, or that the knowledge it conveys will in itself make the fortune of a man or a nation; such knowledge, unless followed up by intelligent enterprise, is useless, as the fate of certain nations proves. But without such knowledge commerce is working in the dark, and commercial geography, it seems to me, more than any other subject, may be regarded as the technical training of the merchant. No doubt, when the student launches into actual business, he may find it necessary to adapt what he has learned to special conditions, just as the chemist or the electrician does after he has had his special technical training. But it seems to me that with such training he is better prepared to carry on the great operations of commerce, in all its bearings and ramifications, and to look after the momentous interests of this great empire much more effectively than if he worked in the dark, guided only by some rule-of-thumb maxims. There are too many enlightened rivals in the field for such a course to be any longer safe, for either the commercial or the political interests of the British Empire.

DISCUSSION.

Mr. C. M. KENNEDY, C.B., said the subject of the paper might be considered to sum up the function of the Society, for the bearing of geography on commerce covered the growth of arts and manufactures, as well as commerce itself. The statements in the paper were so complete and sound that he could only commend their study to all. The eloquent description it had given of the whole subject would afford interesting information to everyone, while the paper was a mine of thought and suggestion for those young men who were engaged in any branch of commercial pursuit. From a practical point of view, he did not think we need be apprehensive of foreign competitors; the English people possessed more money, and had at least as much brains as any other of their competitors, and if our manufacturers and merchants would study the subject with which they had to deal, and become acquainted with the requirements of foreign countries, he did not think they need fear competitors. Our commercial supremacy in the past was not a matter either of accident or favour; the men who carried on the important work of the East India Company, and that of the African, Levant, and Russian Companies, thoroughly studied the subject matter of that which was to engage their attention. Englishmen had a capacity for adjusting themselves to altering circumstances, and this capacity evinced the power of their survival. If, therefore, we made use of the means and opportunities of information now at our command, which would be supplemented by the Imperial Institute which the Chairman was engaged in organising, he felt sure that our manufacturers would be able to hold their own in the world, and would hand down to the future generations the high position they had inherited from their forefathers.

Dr. YEATS said this was a most able and masterly paper; but to speak of commercial geography without stating precisely what commerce was, what it did, and what it required, seemed to him at any rate a slight omission, for one could hardly discuss commercial geography apart from the requirements of commerce. The time was when all commercial men in the country classed themselves under some one of the many different heads, according to their conception of geography. There were the Baltic, Levant, Turkey, North and South African Companies, and so on, each confining its operations to a different trade area. From his point of view, which he put forward simply to provoke further discussion, he would say that the old traders had their own notions of commercial geography, and its foundation was to be seen in the study of human wants, and then the nature of the supplies, and the resources from which those wants were to be met, were considered, and the study of the surface of the earth was made on those simple principles. Every man who went into business belonged to one of the societies who trafficked in those particular regions, and in certain produce, due regard being given not only to the produce itself, but to the return current of goods from these countries, which formed the payment for it. The natural produce of most of those great trading areas had materially changed according to the demand from great distances; for instance, the produce of India largely depended on the demand for it in England. How was it that one country might be largely occupied in the growth of a single raw material like cotton or wool, while another converted it into yarn, another might weave it, and another might make it an article of merchandise? Modern commerce differed essentially from that of a previous period in this fact, that the population, more than the country, must be taken into account. When you saw a country allowing its produce to go elsewhere to be worked up, that country was superficially a stage lower in civilisation than the one which worked up the raw material into a higher condition, and the study of the condition of the people was almost as important as that of the soil itself. One great thing which modern commercial geography had to take into account was the comparative capacity of each country for sustaining its own population. Few countries in Europe at the present time were able to provide for their own people, and nearly all had to purchase from a distance, and in order to obtain the food that they did not grow in sufficient quantities they had to prepare certain products for which their soil might be fitted, but for which they themselves were more fitted. The nature of industry and commerce was now becoming very complicated, and it was very difficult to deal with the various points in the short space of an hour. It was well known that nearly every country had a redundant population; in our country, after making allowance for emigration, there were 700 additional mouths every day to provide for, and the question was, where to send them; what country could commercial geography point out as affording the means of sustenance to those who must leave our shores, or if they remained, under what conditions must they remain? The movements of goods and commodities from one side of the globe to the other were pointed to. And there were equally important movements in the population itself—in what Mr. Leonard Courtney called the swarming of nations. There was hardly a country in Europe in which the agricultural population could find subsistence; they constantly passed from the country into the towns, and from one town to another, as had been shown by Mr. Ravenstein in his paper at the Statistical Society. The population was always moving in the direction of the means of subsistence; they left their own country and went wherever an opening presented itself, and those openings it was for commercial geography to provide. He hoped this paper would be widely read and studied, for by papers and discussions of this kind a way was opened for helping those who did not know how to help themselves.

Mr. W. TOPLEY, F.R.S., said Mr. Keltie, in attacking a subject of such wide range, had to some extent laid himself open to criticism, as it was impossible for him in the time at his disposal to cover the whole ground. As the last speaker had said, one very important point was to understand native character, a point which had been alluded to in the paper, though but slightly; and of course the characters of native races were as important factors in any geographical or commercial researches as the soil or climate. Mr. Kennedy thought the British Empire need not fear foreign competition, because in the past we had shown ourselves such wonderful colonisers, and so on, and no doubt that was true, and under similar conditions we should have nothing to fear; but British pluck and money were not the only things to be considered nowadays, and there was no doubt that foreigners, Germans especially, were at a great advantage, as compared with average Englishmen. When they went abroad to take part in commercial pursuits, they went trained in a manner which was impossible at present in England, for although a great deal was being done to provide geographical knowledge, there was no chair comparable to those at Berlin and Vienna. The authorities in those countries took the very best men they could find and gave them prominent positions, and these men had an enormous influence in the development of German trade. It occurred to him that a great deal might be said as to the important bearing of geology on this subject. Setting aside the very widest considerations of climate, such as the latitude, oceanic currents, prevailing winds, &c., such minor questions as climate had largely a geological significance. The general structure of a country, and the condition of the soil depended solely on geological conditions. The climate modified the soil, and you might have a good soil which could not be utilised, but the quality of it was a question of geology. So, to a great extent, was the distribution of population, even in such a small area as that of England. As had been shown by Mr. J. R. Green, the first settlements were along the outcrops of a certain formation, where water could be obtained, but the later distribution was almost entirely due to the underlying minerals. Some of the diagrams on the wall had not been explained, and he should like to ask Mr. Keltie with regard to that of Canada, whether any of the enormous area unaccounted for might yet be turned to account, and what was the difference between cultivated land and occupied land.

Mr. A. MONTEFIORE said he had brought with him a cutting from the February proceedings of the Royal Geographical Society, which contained a very valuable paper by Colonel Mark Bell, who, in his famous ride from Pekin to the shores of the Mediterranean, learned a vast deal of the geography, especially on the commercial side, of that tremendous region. He said no one could travel through Eastern Turkestan without forming a very high opinion of Russian enterprise; their cottons, chintzes, cutlery, and other goods were found everywhere, and in Foochow he found the Russian merchant, dressed like a Chinaman, pressing the sale of his commodities, which were well suited to his customers. Throughout his journey he was much struck with the want of British commercial enterprise in the interior of China, and he mentioned, as a reason, the poverty of the Russian as compared with the wealth of the English. Throughout China he found clerks and agents of Continental birth even in the British mercantile houses; and he was amazed to find how the English merchants were content to settle at the treaty ports and not attempt to push their trade into the interior. On the previous evening Mr. Wells, in an interesting paper on "Brazil," said that British enterprise in that country was somewhat on the decline, the German and American traders having stepped in to a very large extent. A few months ago Mr. Wells, in conversation, gave him his view as to the cause of this, viz., that the travellers or agents from Germany or the United States came and settled in the country, learned the language, studied the wants of the people, and then wrote home instructions what to send. On the other hand, an English representative would come to Brazil, and in sublime ignorance of the wants and tastes of the people, would say—This is the style of thing we make for such a climate as yours; if you do not like it, you can leave it; or something to that effect. A short time ago the Consul at New Orleans gave an instance of the want of British enterprise. The bottled beer industry was rapidly growing in the United States, and a certain firm there required about 2,000,000 bottles per annum. The Consul said he would write for an estimate to a firm he knew in the north of England and ask them to send samples. He did so, but received no reply for three months, and then on making inquiries received a reply saying the firm wanted a small sum—£5, or something like that—for the cost of the samples. The result was that the bottles were now being provided from Bavaria. Dr. Mill, in an interesting paper read before the Tyneside Geographical Society, referred to the question of human wants as being, with the physical condition, the prime factors in commerce, and he pointed out that the success of the Canadian fisheries was not only dependent on the physical conditions of the great banks where the cod were so plentiful; but also on the observance of Lent by the large Catholic populations of North America and the southern countries of Europe. He would ask Mr. Keltie if he really attached much importance to commercial geography being taught in elementary schools, which, in fact, had been done to a certain extent for a great many years, and whether the great want was not a more specialised and advanced knowledge to be imparted at a later stage, when other students were taking a course in technical education. For such students no text-book would suffice; they ought to go to original authorities, such as consular reports, good books by the best authorities, and the reports in the daily and weekly press.

Mr. KELTIE, in reply, said he had endeavoured to show the bearing which geography had upon commerce, not to give exhaustive instruction in the commercial geography of the world, and this would account for some of the omissions which had been referred to. The question put by Mr. Montefiore he had really answered in the paper; he quite approved of the method suggested and pointed out, that young men going into commerce ought to have such a special training as he referred to. There were one or two text-books; Dr. Yeats himself was the author of one of the best. Of course, he could not go into the minute geology of the whole world, but he quite admitted the importance of the science. With regard to Canada, a large portion of it being in the arctic regions accounted for a large area being practically waste. Land might be occupied without being cultivated; a man might take up 140 or 160 acres, which he would be said to occupy, but he might only clear and cultivate a small portion.

The CHAIRMAN said it was almost a misfortune that such an important subject could not be more thoroughly discussed than was possible in one evening, for there were many aspects of it which might very usefully be elaborated. He felt rather diffident in referring to his own views in the presence of so many authorities who had paid special attention to the subject, but it struck him that a good education in commercial geography depended in a very great degeee on the preliminary training which the student had received, and it was in the development of this preliminary training that the schools in Germany, Russia, France, and Austria were beginning to tell in the great advantages they gave to their commercial men. The subject of geology had been referred to, and he felt sure that unless a young man had a thorough training, not only in geology, but in the principles of the chief sciences, he would cut a very poor figure in commercial geography, as compared with a young man brought up in one of the great continental schools. In order to obtain a thorough knowledge of a country, it was necessary to understand not only its geology, but its meteorology, ethnology, chemistry, botany, and zoology, and a long list of sciences would be required to deal thoroughly with a knowledge of its produce, and the methods of obtaining it, applying it, and transporting it. In this direction he trusted that some advance was being made. He agreed with Mr. Kennedy that in former years our energy, love of adventure, perseverance, and our feeling that we were never conquered, led us on to do what other nations could not or did not think of doing, but those times were past, and we were put on an equality with other nations in those respects. Although we still had those sterling qualities which led us on to meet and conquer difficulties, we now had to meet adversaries who had been trained physically and mentally to cope with us. He trusted the Imperial Institute would in time do a great deal towards providing those opportunities for training which at present did not exist to any thing like the full extent. The department of commercial intelligence which the Institute was already organising would, he hoped, greatly help in providing for the want which had existed for training those who devoted themselves to the higher branches of commerce, and also provide a place of reference on all matters connected with the commercial history and commercial relations of other countries; and that the sample collections which would ere long begin to be organised, would represent what the great industrial and trade museums of other countries supplied. He concluded by proposing a cordial vote of thanks to Mr. Keltie for his extremely able and valuable paper, which was carried unanimously.

Correspondence.

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INDIAN CATTLE MANURE.

In connection with the interesting paper on "Indian Agriculture," read at the Society's rooms on the 13th inst., by Professor Robertson, the following analysis of cattle manure, as collected from the field (in fact the usual sun-dried bratties used for fuel), may be of interest.

The manure was sent specially from India, and carefully analysed in my laboratory some three years since, and may therefore be taken as a reliable sample, though of course the quality of such manure will vary with the nature and richness of the food according to the pasture fed upon, and the time of the year:—

Water (dried at 212° F.)	7·22
*Organic matters	65·32
Lime	1·96
Potash	·63
Soda	trace
Phosphoric acid	·54
Magnesia, chlorine, sulphuric acid, &c.	5·71
Insoluble siliceous matters	18·62
	100·00

From these results it is evident that every ton of such sun-dried manure contains in round numbers the following quantities of the important plant food constituents:—

	lbs.
Lime	43
Nitrogen	33
Potash	14
Phosphoric acid	12
	102

When such manure is burned, the nitrogen, which exists in the form of organic matter, becomes converted into gaseous products in the process of combustion; but the mineral matters, which include the lime, potash, and phosphoric acid, remain in the ashes, and if these were returned to the land the only loss would be the 33 lbs. of nitrogen, equal to 155 lbs. of sulphate of ammonia, for every ton of cattle manure so employed.

JOHN HUGHES, F.C.S.,
Consulting Analyst to the
Ceylon Planters' Association.

79, Mark-lane,
March 17th, 1890.

AGRICULTURE AND THE STATE IN INDIA.

Mr. A. ROGERS (formerly Settlement Officer) writes:—

"In the first place, it was very evident that Mr. Robertson had, like many people who have not been directly connected with British administration in India, a very crude idea of our position as landlords. We derive a large proportion of our revenue from the land-tax, and can sell a man's tenant right if he does not pay the dues of the State, but we can do so for no such cause as his not manuring his land according to our notions, or making use of that rotation of crops which we may consider scientifically correct. It is one of the privileges conferred on the ryot in any revenue settlement that he can do anything he chooses with his fields as long as he pays the revenue. No one will for a moment deny that proper rotation, manuring (not in all cases), irrigation, &c., are very advisable both for the ryot himself and to increase the general prosperity, but he must adopt them of his own accord, guided, if possible, by the collector's advice, but in no case on the order of that officer.

The only really practical way suggested by Mr. Robertson in which agriculture in India can be advanced by the action of the State, beyond providing improved facilities for irrigation and good communications, is in the encouragement of small local works such as village tanks and wells in fields, and improved methods of drawing water from such works. If there were a tank under which rice or sugar-cane could be grown in every village, and a well from which he could raise an irrigated crop in every man's field in case of failure of the monsoon rain, we might defy all future famines. I am quite aware that this policy has not been lost sight of, for great facilities are afforded individual ryots to take up loans at moderate rates from the State, for the improvement of their lands on the security of the latter, in addition (at all events in Bombay) to the full value of such improvements being secured to them by law in perpetuity. These facilities have, however, not been taken advantage of by the ryots to the extent which might have been expected, on account of their dislike to submit to be bound by the formalities with which the State has necessarily to protect itself against loss in making the loans. Discouraging as this is, the efforts made in this direction must not be relaxed, and it is to be hoped that by degrees, if all unnecessary formalities are carefully dispensed with, a more general recourse will be had to such land, to the benefit of the individual ryot and the State.

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* Containing nitrogen, 1·48.

Another point in which I entirely disagree with Mr. Robertson is with regard to his apparent idea that the extension of the area of cultivation and consequent contraction of that of waste have the injurious effect of lessening the supply of manure. Manure in Bombay is never derived from such waste except in the single instance of the dry grass in some parts being made use of to burn on rice lands. In every other case it only serves to perpetuate the race of miserable half-starved cattle, kept by the people in hope of some small profit from them simply because they incur no expense or trouble in keeping them. In preparing a history of the Land Revenue Administration in Bombay, I have had to study the statistics of agricultural stock before and after the introduction of the Survey settlements, and one of the most favourable symptoms of their effect is, to my idea, the disappearance of this useless class of beasts, and the steady increase of really useful plough cattle. Moreover, in the most fertile districts of Guzerat, Broach, for instance, where over 90 per cent. of the whole arable area is under the plough, the cattle are the finest, for the simple reason that there is no waste ground from which useless beasts can pick up a precarious substance, and the ryot has to provide for his really good agricultural bullocks (and this, by the way, by a system of rotation of crops which he thoroughly understands) kurbee (jowari and bajri stalks) with which to feed them at home.

The multiplication of institutions in which the ryots may learn the science of agriculture in those stages up to which the practical knowledge of their ancestors has not reached is highly commendable, but this, as Sir C. Bernard stated, is not being neglected.

BRITISH WATCH AND CLOCKMAKING.

Mr. Samuel Jackson writes to correct a passage in the report of his remarks in the discussion on Mr. Tripplin's paper (see *ante*, p. 378, col. 2). It was the expenses of the exhibit at the Paris Exhibition of the School of Horology which, he wished it to be understood, were paid by the British Horological Institute, not the expenses of the establishment of the school.

Obituary.

John Standfield, M.Inst.C.E. — Mr. John Standfield, senior partner in the firm of Standfield and Clark, of Victoria-street and Grays, Essex, lost his life in the wreck of ss. *Ville de Calais* off Margate, on Sunday morning, 2nd inst. He had purchased the wreck of this vessel in Calais harbour, and a portion was being towed to his yard at Grays, when it encountered a terrible snowstorm off the North Foreland. Mr. Standfield, with others on board the vessel, then took to the boat, which was upset in being lowered into the sea, and he and some of the others were drowned. Mr. Standfield was employed in many engineering works, especially in the construction of floating docks, and he was professionally connected with the successful raising of the *Orient* in Sydney Harbour. He was elected a member of the Society of Arts in 1881.

Thomas Gray, C.B.—Mr. Gray, Assistant-Secretary of the Board of Trade (Marine Department), died on the 15th inst. Mr. Gray was born in 1832. He entered the Board of Trade as boy clerk in 1851. He took a special interest in the many branches of work connected with his department. The rules of the road at sea, as they at present exist, were to a large extent formulated under his superintendence, and the rhymes which he devised, as a sort of *memoria technica* for them, are familiar all over the world. Mr. Gray became a member of the Society in 1885, and though his official position prevented him from taking any actual part in the committees of the Society dealing with matters in which he was interested, such as life-saving apparatus, sound signals at sea, &c., he took great interest in their work, and on many occasions aided unofficially, but to a very large extent, in their labours.

General Notes.

Silk Association.—The Ladies' Committee of the Silk Association, under the presidency of H.R.H. the Princess Mary Duchess of Teck, have drawn up a report for the year ending February 28th, 1890, in which they announce that they "propose to form a Ladies' Silk Association on an extended scale. Its members will not be pledged (any more than are the members of the ladies' committee) to the exclusive purchase and use of English made silks, but they will be asked to interest themselves and their friends in this British industry, and to make inquiry for, and inspect English silks before deciding to purchase those of foreign manufacture. In conclusion, the Ladies' Committee of the Silk Association trust that before long ocular demonstration of the excellence of English silks may be afforded by an Exhibition; and should success crown the efforts of those who have been working on behalf of the silk operatives of England, Scotland and Ireland, they will feel rewarded by the knowledge that the time and energy they have devoted to this enterprise have resulted in increased material prosperity to their working brothers and sisters in silk factories."

FRENCH COAL PRODUCTION IN 1889.—Comparative Tables relating to the coal production in France have recently been prepared and issued by the French Government. From these Tables it appears that the total production of coal in France, in 1889, amounted to 24,588,880 tons, as compared with 22,602,894 tons in 1888, an increase of 1,985,986 tons. The largest quantity came from the Department of the Pas de Calais, namely, 8,624,837 tons, while the Nord furnished 4,809,065 tons, as compared with 4,416,185 tons in the preceding year. The Loire comes next with 3,378,138 tons, the Gard with 1,976,511 tons, and the Saône at Loire with 1,491,279 tons. In the Departments of the Pas de Calais and the Nord, the largest quantity of coal extracted came from the mines of the Anzin Companies, the amount being 2,857,613 tons; the Lens et Douvrin Company comes next with 1,667,398 tons, and the Courrières Company with 1,188,635, the increase in the production in 1889 over that of the preceding year being 262,032, 255,747, and 95,435 tons respectively. The increase in the total production of these two departments amounts to 1,057,413 tons, the actual amounts being 13,433,847 tons in 1889, against 12,376,434 tons in 1888.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

MARCH 26.—G. N. HOOPER, "Carriage Building and Street Traffic in England and France." COLONEL SIR NIGEL KINGSCOTE, K.C.B., will preside.

Papers for Meetings after Easter:—

APRIL 16.—TALBOT B. REED, "Old and New Fashions in Typography." Dr. GARNETT, Keeper of the Printed Books in the British Museum, wil preside.

APRIL 23.—WILLIAM WHITAKER, F.R.S., "Coal in the South-East of England." ARCHIBALD GEIKIE, LL.D., F.R.S., will preside.

MAY 7.—DR. PERCY F. FRANKLAND, "The Aim and Scope of Higher Technical Teaching."

MAY 14.—ELIHU THOMAS FLEMING, "Electro-Magnetic Indicator Experiments."

FOREIGN AND COLONIAL SECTION.

Tuesday afternoons, at Five o'clock:—

APRIL 22.—SIR JOHN STOKES, K.C.B., "The Danube and its Trade."

A. LASENBY LIBERTY, "The Industrial Arts of Japan."

C. G. WARNFORD LOCK, "Gold Mining in Hungary."

INDIAN SECTION.

Thursday afternoons, at Five o'clock:—

MAY 22.—SIR J. THEODORE HOPE, K.C.S.I., "The Rationale of Indian Railways." The MARQUIS OF RIPON, K.G., will preside.

[The Meetings of this Section will in future be changed from Fridays to Thursdays.]

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock:—

MARCH 25.—W. J. LINTON, "Engraving in Wood, Old and New."

APRIL 15.—C. PURDON CLARKE, C.I.E., "Modern Indian Art."

MAY 13.—Prof. W. C. ROBERTS-AUSTEN, F.R.S., "The Use of Alloys in Art Metal-work."

CANTOR LECTURES.

Monday evenings, at Eight o'clock:—

A. H. CHURCH, M.A., F.R.S., Professor of Chemistry in the Royal Academy, "Some Considerations concerning Colour and Colouring." Three Lectures.

LECTURE II. — MARCH 24. — Complementary colours. Contrast of tone and colour. Harmonies of colour. Combinations of colour, dyads, triads, tetrads, &c. Separation of related hues. Throbbing colour.

LECTURE III.—MARCH 31.—Balance, proportion, and distribution of colour. Counterchange and interchange of colour. Colours of natural and artificial materials. Decorative and pictorial colour. Colour in relation to architecture and sculpture.

POPULAR LECTURES.

Saturday afternoons, at Three o'clock:—

Professor VIVIAN LEWES, "The Atmosphere." Four Lectures.

LECTURE III.—MARCH 22.—Carbon dioxide in the air. How it is formed, and why it should not be present in air in larger quantities than six parts in ten thousand. Respiration. The action of the heart and lungs, and the part played by the air in supporting life. Nature's laws for keeping the composition of the air constant. Plant life and diffusion of gases.

LECTURE IV.—MARCH 29.—Local impurities in air. Germs and the propagation of disease. Decay. Purification of the air by rain and oxidation. Ozone. The air of enclosed spaces, and the amount of fresh air required for health. Ventilation. The formation of air currents. Draughts. The effect of our methods of heating and lighting rooms upon health. Conclusion.

The regulations for admission will be the same as for the Cantor Lectures, each member having the privilege of admitting a friend.

ADDITIONAL LECTURES.

Thursday evenings, at Eight o'clock :—

LEWIS F. DAY, "Design applied to Wood-Carving." Three Lectures.
May 1, 8, 15.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MARCH 24...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Prof. A. H. Church, "Some considerations concerning Colour and Colouring." (Lecture II.)

Surveyors, 12, Great George-street, S.W., 8 p.m. Adjourned discussion on Mr. T. W. Wheeler's paper, "Betterments."

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Mr. Augustus Allen Hayes, "North American Trans-Continental Pathways; Old and New."

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Rev. Canon Benham, "Beginnings of Modern Europe." (Lecture III.)

TUESDAY, MARCH 25...SOCIETY OF ARTS, John-street, Adelphi, W C., 8 p.m. (Applied Art Section.) Mr. W. J. Linton, "Engraving in Wood, Old and New."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. G. J. Romanes, "The Post-Darwinian Period." (Lecture X.)

Medical and Chirurgical, 20, Hanover-square, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Discussion on Mr. James Price's paper, "Lough Erne Drainage." 2. Mr. John Robinson, "Barry Dock and Railways."

Anthropological, 3, Hanover-square, W., 8½ p.m. 1. Exhibition by Mr. Isidore Spielman of a Skull dredged up on the Manchester Ship Canal Works. 2. Mr. Henry Balfour, "The old British 'Pibcorn,' or 'Hornpipe,' and its Affinities." 3. Mr. Hector Maclean, "The Ancient Peoples of Ireland and Scotland considered."

Horticultural, Drill-hall, James-street, Victoria-street, S.W., 3 p.m.

Historical and Archæological Association of Ireland, Royal Dublin Society's House, Kildare-street, Dublin, 8 p.m. 1. Rev. Denis Murphy, "The Wogans of Rathcoffey." 2. Rev. Leonard Hassé, "Objects from the Sandhills at Portstewart and Grangemore, and their Antiquity." 3. Mr. W. F. Wakeman, "Ancient Stone Implements" (in Rev. Canon Grainger's collection." 4. Mr. Jame Coleman, "The History of an Irish Island." 5. Exhibition by Mr. William Frazer, "Celts and other Implements from Scandinavia."

WEDNESDAY, MARCH 26...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. G. N. Hooper, "Carriage Building and Street Traffic in England and France."

Geological, Burlington-house, W., 8 p.m. 1. Miss Coignou, "A new Species of *Cyphaspis* from the Carboniferous Rocks of Yorkshire." 2. Mr. F. Rutley, "Composite Spherulites in Obsidian from Hot Springs near Little Lake, California." 3. Mr. G. R. Vine, "A Monograph of the Bryozoa (Polyzoa) of the Hunstanton Red Chalk." 4. Mr. W. S. Gresley, "Evidence furnished by Quarternary Glacial-epoch Morainic Deposits of Pennsylvania, U.S.A., for a similar mode of Formation of the Permian Breccias of Leicestershire and South Derbyshire."

United Service Inst., Whitehall-yard, S.W., 3 p.m. Surgeon-Major J. Lane Notter, "Sanitation of Barracks."

Naval Architects (at the HOUSE OF THE SOCIETY OF ARTS), 12 noon. Annual Conference. 1. Presidential Address. 2. Mr. W. H. White, "Notes on Recent Naval Manœuvres." 3. Admiral Colomb, "The Maritime Conference."

Royal Society of Literature, 21, Delahay-street, S.W., 8 p m.

Botanic, Inner Circle, Regent's-park, N.W., 2 p.m. Exhibition of Spring Flowers.

Inventors' Institute, 27, Chancery-lane, W.C., 8 p.m.

THURSDAY, MARCH 27...Naval Architects (at the HOUSE OF THE SOCIETY OF ARTS), 12 Noon. 1. Captain C. C. Penrose Fitzgerald, "Leak Stopping in Steel Ships." 2. Professor P. Jenkins, "Strength of Ships, with special reference to Distribution of Shearing Stress over transverse Section." 3. Mr. Frank C. Goodall, "Steatite as a Pigment for Anti-Corrosive Paints." 7 p.m. 1. Mr. C. E. Stromeyer, "The Evaporative Efficiency in Boilers." 2. Mr. A. Betts Brown, "The Application of a System of Combined Steam and Hydraulic Machinery to the loading, discharging, and steering of Steam Ships." 3. Mr. Arthur Rigg, "The Revolving Engine Applied on Board Ship."

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Chemical, Burlington-house, W., 4 p.m. Anniversary Meeting.

London Institution, Finsbury-circus, E.C., 6 p.m. Dean of Winchester, "Mediæval Commerce."

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Miss Oliveria Prescott, "A Phase of Realism in Music." (With Illustrations.)

Royal Institution, Albemarle-street, W., 3 p.m. Mr. F. Niecks, "The Early Developments of the Forms of Instrumental Music." (Lecture IV.)

Electrical Engineers, 25, Great George-street, S.W., 8 p.m. Hon. Newman Lawrence, "Alternate and Continuous Currents in Relation to the Human Body."

Ladies' Sanitary Association, 22, Berners-street, W., 3½ p.m. Mrs. Dacre Craven, "Home Nursing."

Camera Club, Bedford-street, Strand, W.C., 8 p.m. Mr. Willis, "Platinotype Possibilities."

FRIDAY, MARCH 28...Naval Architects (at the HOUSE OF THE SOCIETY OF ARTS), 12 Noon. 1. Mr. T. C. Read, "The Variation of the Stresses on Vessels at Sea due to Wave Motion." 2. Professor Vivian Lewes, "Spontaneous Combustion in Coal Ships." 7 p.m. 1. Mr. James Howden, "The Screw Propeller." 2. Mr. J. Corbett, "Experiments with Life-boat Models."

United Service Inst., Whitehall-yard, S.W., 3 p.m. Colonel the Right Hon. J. H. A. Macdonald, "Infantry Training."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Lord Rayleigh, "Foam."

Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. Alfred E. Young, "Deflection of Spiral Springs."

Clinical, 20, Hanover-square, W., 8½ p.m.

Browning, University College, W.C., 8 p.m. Prof. E. Johnson, "Fifine."

SATURDAY, MARCH 29...SOCIETY OF ARTS, John-street, Adelphi, W.C., 3 p.m. (Popular Lectures.) Prof. Vivian Lewes, "The Atmosphere." (Lecture IV.)

Royal Institution, Albemarle-street, W., 3 p.m. Lord Rayleigh, "Electricity and Magnetism."

Journal of the Society of Arts.

No. 1,949. Vol. XXXVIII.

FRIDAY, MARCH 28, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

By kind permission of the Trustees of the British Museum, the Society's *Conversazione* will be held this year at the Natural History Museum, South Kensington. Particulars as to date, &c., will be announced later on.

POPULAR LECTURES.

On Saturday afternoon, 22nd inst., Professor Lewes gave the third of his course on the "Atmosphere," and explained the source and action of the carbon-dioxide present in the air. Having experimentally demonstrated the composition and properties of the gas, the lecturer pointed out the processes taking place during respiration, showing that the warmth of the body was due to a process of slow combustion, by which the used up tissues of the body were converted into carbon-dioxide and water vapour, by oxygen carried by the arterial blood from the lungs, and that the products of this combustion were partly got rid of by the skin, and partly brought back by the blood, and discharged into the air from the lungs. Not only is carbon-dioxide largely produced in this way by all forms of animal life, but it is also a product of combustion, fermentation, and decay, no less than 3½ million tons of oxygen being daily extracted from the atmosphere and replaced by carbon-dioxide. This enormous drain upon the oxygen present in the air would rapidly deteriorate its qualities, were it not that the growth of vegetation is dependent upon the property possessed by the green colouring matter present in plants, of absorbing and decomposing carbon-dioxide under the influence of the sun's rays, and utilising the carbon to form the woody fibre of the plant, whilst oxygen is returned to the atmosphere.

The action of plant life, however, would be of but little avail if it was not aided by the circulation of air brought about by wind, and by a property which all gases possess of intermingling, the heavy carbon-dioxide generated in large towns being evenly mingled with the other constituents of the atmosphere, so that in sunny climes, rich in vegetation, its decomposition is insured, whilst the same forces bring back the liberated oxygen to the towns.

CANTOR LECTURES.

The second lecture of the course, entitled "Some Considerations concerning Colour and Colouring," was delivered by Professor A. H. Church, M.A., F.R.S., on Monday evening, 24th inst.

Proceedings of the Society.

FOREIGN & COLONIAL SECTION.

Tuesday, March 18, 1890: Hyde Clarke in the chair.

The paper read was—

BRAZIL.

By James W. Wells, M.Inst.C.E., F.R.G.S.

The startling events which have recently happened in Brazil undoubtedly have been the means of attracting a world-wide attention to that vast country, and especially by Englishmen, to a region where their interests are much more involved than is generally supposed. Firstly, we had the news of the sudden unconditional abolition of slavery on the 13th May, 1888, when, amidst a delirium of wild excitement and popular rejoicings throughout the country, a half-million of human beings were restored to freedom. Then, on the 15th November of last year, the monarchical institutions of sixty-eight years crumbled away to dust; the aged and respected Emperor was banished; and on the morning of that eventful day the astonished Brazilians awoke to find themselves citizens of a republic. That two such powerfully dramatic incidents of a nation's history should pass through the travail of such events, and successfully attain the ends aimed at without bloodshed or hardly any disturbance of the peace, render them worthy of a prominent place amidst the great happenings of the past, for to attain such vast results with as little effort is certainly unique in history.

The details of these events have been so thoroughly discussed, and are now so well known, that I will not detain your attention in attempting to recapitulate them. They were well described in the *Times* of the 11th December last, and later information has contributed nothing to controvert that synopsis of an eventful era in Brazilian history. However, I cannot let the subject pass without a few remarks upon it.

With all the liberty enjoyed under the tolerance of the old monarchical rule, republican aspirations had for many a year gone by taken deep root in the minds of a considerable section of the Brazilian people. During the last few years especially the republican party continually received numerous adhesions to its numbers, which showed that in course of time, more or less distant or near, Brazil must necessarily cease to exist as the only monarchy of South America. The question was one of time, of time only. For even as the popularly received edict which determined the extinction of slavery failed to prolong for a day the existence of the empire, neither would the most liberal reforms have assured for many decades the stability of the empire. Still amongst the majority of the Brazilians the fall of the empire was looked upon as being more or less remote. Even after the notorious successful insubordination of the military classes against the Cabinet of the 7th June last, the events of the 15th November last incontestably created throughout the country a feeling of bewildering astonishment, but after the first shock of surprise had disappeared, the news was generally well received. The impossibility of armed resistance, the helplessness of the old governing powers, caused undoubtedly even the wavering to accept with a good grace the inevitable. Moreover, many of the past social and economical conditions of the empire rendered the new order of things very acceptable. For instance, the enormous area of Brazil, with its vast distances and scanty means of communication, practically rendered impossible the continued existence, at Rio de Janeiro, of the old system of central government. The many varying conditions of local interests of the hitherto provinces, now states, both social and economical, were so little appreciated by the central Government, that an antagonism to that power had always more or less existed throughout the then empire. It is true there was indeed a limited form of home government already existing in the provinces, nominally by means of deputies to a provincial assembly; really, however, it was in the hands of the president of such an assembly, one who more often than not was a stranger to the province he governed, and, of course, an alien to its interests, and invariably nominated to his post by the political party in power at Rio. The actual difficulties of the situation, with their required remedies, were, perhaps, hardly grasped by the provincials, but a feeling of strong discontent was ever prevalent, and the discontent was expressed in cries for republicanism or secession; and, doubtless, had many of the various individual provinces of the empire possessed the slightest prospect, in wealth and armed forces, of being able to resist successfully the collective power of the empire as centralised at Rio, I feel sure that long ere this we should have seen a disintegration of the State. But knowing, as I did, the power of the old *régime* to resist and overcome any efforts at secession, I have long and heartily combated the idea of the probability occurring of any split up of the empire, and I feel that the homogenity of the State, in the new form of a republic of federated States, is still more assured.

The proposed institution of home rule in every State, on the principle of the United States of America, will undoubtedly confer a reign of peace, progress, and prosperity, where hitherto discontent was perpetually rampant, and will create a popular sense of satisfaction, and a union of interests which could not possibly have existed under the previous conditions. Hence it may be contended that the new order of things is much more likely to be productive of a lasting union of strength and general interests than could have happened if the old causes of discontent had continued to exist.

One other factor is also worthy of being noted by those who, as I do, look forward to a peaceful exit out of the present chaos, and that is the essentially pacific character of the Brazilian race when compared with those descended from Spanish stock in the adjoining republics.

Probably no one in the late empire was more ready to admit the advisability of the change that has occurred in the constitution of the country, than the late Emperor himself. Certainly there was no man more democratic than himself. The marvel is that he did not propose what he probably ardently desired, namely, to see his well-beloved country governed by republican institutions with himself as its first President. I feel assured he would gladly have relinquished even the mild pretensions to the glamour of royalty assumed by his simple court for the more homely simplicity of a presidency. Undoubtedly the well-known republican tastes of the ex-Emperor largely contributed to the dissemination of republican ideas throughout the civilised regions of his domains, and, consequently, when the leaders of a successful military revolt against the ministry of the day found themselves masters of the executive power, probably as much to their astonishment as to that of the population of the country, they seized the opportunity to raise the flag of republicanism in a land only too ready to welcome it. Yet I feel sure that respectful sympathy throughout the country will always follow the personality of the ex-Emperor, wherever he may be, but for peace and quietness sake it will be admitted he is better away, at least until the new order of things is firmly established on a constitutional basis, and when that is once done by the voice of the country, probably Dom Pedro himself will be, if in health, amongst the first to welcome it and recognise it. That such will be the case may be judged from the enunciated views of the ex-Emperor in his conference last May with the venerable Senator Saraiva, when that gentleman proposed to him a more liberal policy of government, including great and beneficial changes of the constitution. The result of that conference was thus related by the Senator in the Senate:—

> "Then," said his Majesty to me, "No one knows better than yourself, that never have I been an embarrasment to the expressly manifested desires of the nation." To which I replied, "I know that the patriotism of your Majesty is such that it attends only to the interests of the nation without consulting any other consideration." On hearing these words his Majesty replied to me with considerable emotion, "I thank all who think thus, for they do me justice."

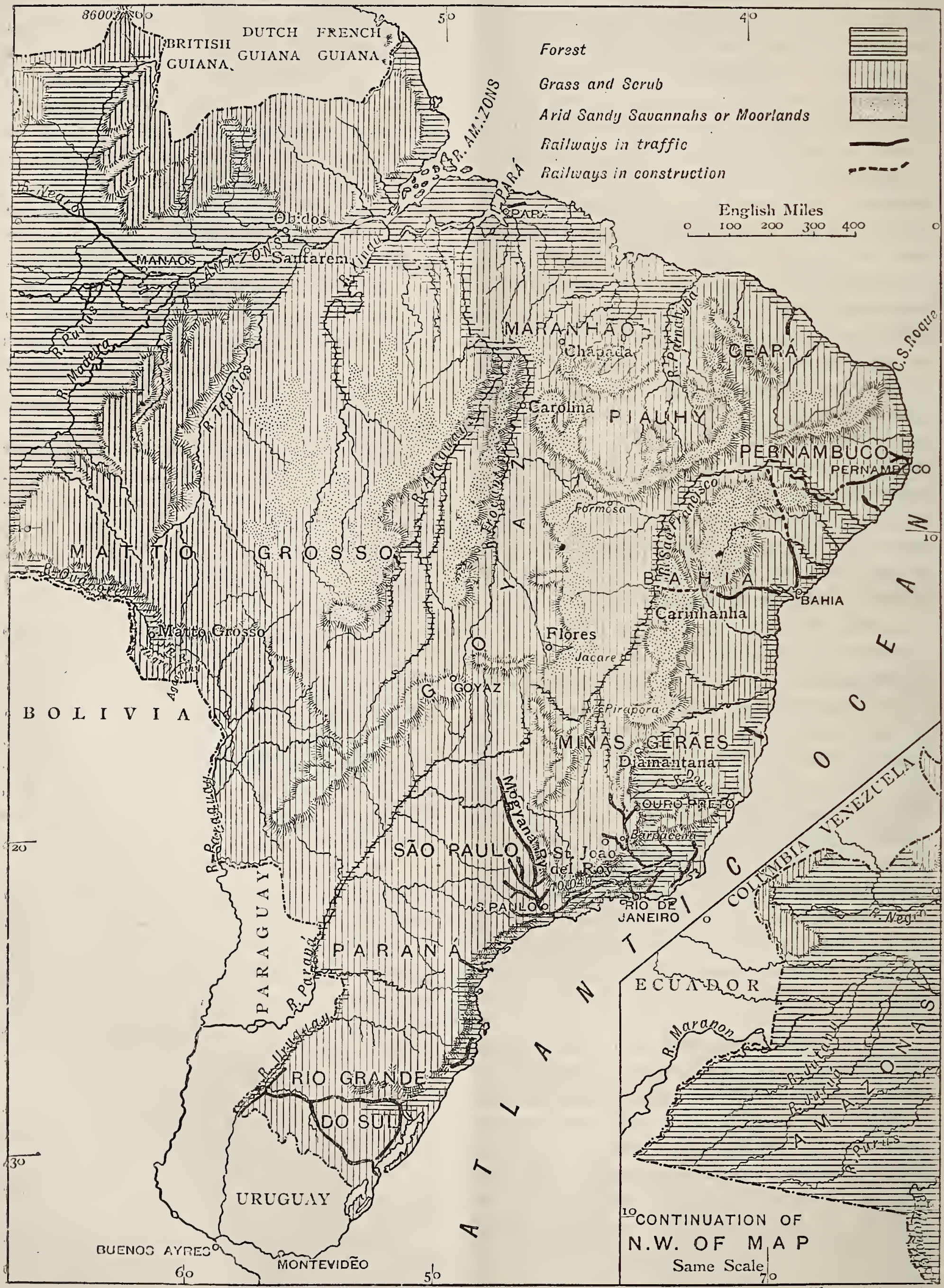
To-day the prominent question with regard to Brazil is what is going to happen next, and will Brazil settle down peaceably under the new order of things? Those are really questions which of course no one can really answer, all we can do is to form conjectures based upon a knowledge of existing facts; and in order that you may form your own opinion, I now purpose to briefly deal with the main features and interests of the country, and make such observations thereupon in a purely unbiassed spirit, as may enable you to arrive at some reasonable conclusion. Nevertheless, I feel that an effort to convey a general notion of Brazil with all its immensely varying features — social, economical, and physical—within the limited time at my disposal will be a vain one, and forcibly recalls to mind Mr. Barnum, when he was requested to describe within the compass of an hour the incidents of his eighty-one years' life. "Why, boys and girls," said he, "you might as well try to make a half-pint of salt water represent the roaring Atlantic."

However, I will now endeavour to say something upon the physical features of the country, and its commerce, means of communications, industries, finances, &c., in order that by considering what Brazil has done and is doing you may arrive at some conclusion as to its immediate future.

In area, Brazil ranks fifth amongst the great nations of the globe, for it contains 3,219,000 square miles, or space enough to accommodate nearly 56 Englands and Wales. Its extent, in a straight line from north to south, is 2,660 miles, and from east to west 2,700 miles, and it contains a coast line of 4,920 miles. Therefore, its area is sufficiently large not only to command respect, but to practically illustrate that the hackneyed phrase, the resources of Brazil, is really something tangible, in the form of land at least, not perhaps of absolute value in itself at the moment, but on the principle of "unearned increment," when future means of communication may render available to settlers the rich waste lands of the State which now, without means of access to markets, are of no value to anyone but Indians.

I will now ask attention to the wall map constructed by the Royal Geographical Society to illustrate my paper on "The Physical Geography of Brazil," and now kindly lent by that society.

This map is intended to convey an idea of the general configuration of the surface of the land and the character and distribution of the vegetation with which it is clothed. It will be observed that all the southern coast line appears to be of an exceedingly mountainous character, and so it also appears from a sea



Walker & Boutall sc.

view, but these elevations are but the bluffs of the great undulating table-land comprising the major part of the country. It is this fact that hitherto has made railways in Brazil so costly to build when compared with those of the flat plains of the Argentine Republic, but now that the ascent from the coast to these upper regions has been obtained, as in Paraná, Sao Paulo, Rio de Janeiro, and Minas Geraes, the future work of extending the railway system of Brazil will be in comparison free from the great difficulties, the great cost and severe gradients of the earlier lines; hence it is that we see what great progress has been made and is making in Sao Paulo and Rio Grande do Sul, where in the former the Mogyana line is well on its way to the central regions, and in the latter where the locomotive is on its way to the south-western boundaries of the land.

As this great table-land slopes from the coast to the interior, many of the great rivers of the country have their sources comparatively near the coast. Railways are following the courses of these streams to reach the points where long lines of navigable waters commence, and thus bring within reach of utility some thousands of miles of economical fluvial communication.

The forest area, the regions of campos or prairies, and the dry and sandy wastes of the interior are shown on the accompanying map (p. 448).

It is, I believe, a popular impression that Brazil is covered with one vast primeval forest abounding in all the wonders of the vegetable world. It is, indeed, true that the great plain of the Amazons, as Humboldt described that great hollow, is covered with perhaps the greatest forest of the globe, one some 1,300 miles long by 800 miles broad; and the river valleys and eastern slopes of the table-lands are also forested, but with these exceptions the rest of the country may fairly be described as campos land, or land covered with grass or grass and bush with scattered clumps of forest, quite park-like in appearance. The atmosphere of these grass-covered table-lands is most delightful and exhilarating. To really appreciate it, one must have resided or worked for some months amidst the dark cathedral-gloom of the forest, in the stilled and humid air, impregnated with myriad odours of fragrant or offensive plants and rotting vegetation; worried by the sting and the monotonous hum and drone of insects; bewildered by the everlasting maze and tangle of colossal trees and creeping, twining, festooned vines, and experience the sense of grim solitude and mental depression that the shady gloom engenders, and then emerge from one of these forested lowlands, like from night to day, out on to the bright and breezy uplands of the campos, sparkling with sunlight, gemmed with countless flowers, fragrant with sweet perfumes, fresh and bracing in the pure brisk wind, and lively with the sounds of birds whistling, screaming, and carolling a noisy concert, then how fatigue and depression seems to disappear, how revived one feels when one inhales that pure serene atmosphere full of ozone, eagerly and with boyish inclinations to shout, to gallop your horse, anything to express your feeling of ecstacy and delight.

From the savannahs of Roraima in the extreme north, right through Brazil to its southern confines, is found on these uplands this glorious atmosphere. But, delightful as it is, this campos land, north of, more or less, the 20° of latitude, is unfitted for anything but pastoral purposes. Southwards, however, the soil of the campos greatly improves in quality, and much of it can be adapted to the cultivation of cereals.

Before leaving this geographical section of our subject, I should like to point out a very interesting feature in the composition of the South American Continent similar to what exists in that of the North—namely, the great hollows or depressions which traverse alike both continents from south to north. For instance, in the South America a steamer can proceed from Buenos Ayres to Cuyabá, a distance of 2,400 miles, and a boat can proceed from the Rio Paraguay up the Rio Agoapehy, whence it can be—as has been done—hauled across a narrow strip of land to the Rio Alegré, where, on the divide of the River Plate and Amazons basins, the elevation is not more than 600 feet above the sea. From this point there is an uninterrupted fluvial communication (excepting where rapids occur) right away to the Amazons and then *viâ* the Rio Negro and Orinoco to the Spanish main. Thus it is possible to traverse this mighty continent from Buenos Ayres right through the heart of the land to the most northerly point without passing a higher elevation than 600 feet above the sea. What a route for a railway! Nature evidently indicates it as the future main arterial communication of the continent, and as a means to connect with the outside world all the rich regions of Bolivia and Peru west of the Andes, and also those of the central regions of Brazil. In fact, the most northerly railways of the Argentine Republic are already well on their way in this direction, and Bolivia has lately contracted to extend those lines through her territory still in this direction, while Brazil has attempted more than once to build a line from the Maderia to the Mamoré.

On the other hand, Brazil, by means of the highly successful and enterprising Mogyana Railway Company of Sao Paulo, is well on its way to Goyaz, and thence probably to the centre of this great natural line of communication. The extremities of this great system would consequently be Buenos Ayres in the south, Santos in the east, and Manaos in the north.

You will see by the course of the lines on the map that the extension of the Mogyana Railway from Sao Paulo to these central regions will be, as a system, an extremely important one, for by means of comparatively short branches it will be able to link together the navigable sections of immense rivers such as the Paraná with the Tocantins, and Araguaya ; the Paraguay with the Guaporé, Tapajos, Zingu, and Araguaya ; the head waters of all these northerly flowing rivers being very slightly separated from those of the rivers flowing south. Of course it is now premature to discuss such a vast system of communications under the present circumstances of these central regions, but I have drawn attention to the matter, as I think it quite possible that the rapid march of the world's progress may lead to a development of these long-neglected regions of natural wealth much sooner than would be supposed ; in fact, there are, I know, certain projects on foot which will very much tend to realise this belief. For instance, on the 22nd of February last, the Pan-American Congress, sitting at Philadelphia, received a report from its railroad committee, declaring that a railway should be built connecting the nations of North, Central, and South America, utilising existing railways when possible. Much, indeed, might be advanced both in favour of, and in opposition to, the prospects of a successful development of these regions, but all in all there are conditions favourable to healthy and prosperous colonisation of territories now in as wild a state as were any of those traversed by Mr. Stanley in Africa ; but it will require time, men, and money to produce it.

COMMERCE AND INDUSTRIES.

It is now just 360 years, so far as is known, since England commenced business with Brazil through Master William Hawkins, of Plymouth, father of the celebrated Sir John of that ilk, who sent out the *Paul*, a ship of 250 tons, in the year 1530. But half a century elapsed before the pioneer of British merchants in Brazil settled in that country, namely, John Whithall, at Santos, in 1581. The French were, however, in the field of Brazilian trade before the English ; then the Dutch for a long time domineered, and actually possessed the northern regions. However, since the country, in 1808, was opened to the ships of the world, the English have absorbed, and still maintain, the major part of the foreign trade of Brazil ; but although we are doing, more or less, year by year, the same amount of trade with the country as we have done during the past decade, we have certainly lost the preponderating position we once held in the general trade of the country. Other nations are now keenly competing with us, and competing successfully, and absorbing to themselves that share of the general increase of trade which, in ordinary circumstances, would have fallen to us. This is a matter which I have fully gone into before a meeting of the London Chamber of Commerce ; what I wish to lead up to by these few observations is rather by means of a few figures to show what progress Brazil has made in her commerce during the last few years, so that we may arrive at an idea of its value in the near future.

In 1867, the foreign trade of Brazil was about £36,000,000, now it is about £50,000,000. In 1867, the foreign carrying trade amounted to about 4,000,000 tons shipping, now it is about 10,000,000. These figures are taken from official statistics, and the great increase of the carrying trade, when compared with that of the values of commerce, show clearly that in quantity Brazil has done a much larger business than values would indicate. That is somewhat explained when one compares the values of the day with those of 1867, yet hardly sufficient to account for so great a discrepancy as appears. Still I give the official figures as I have found them. Although England still does a large export trade to Brazil, yet formerly we commanded much more than a half of the import trade of Brazil; we now only supply about 40 per cent., and consume barely 10 per cent. of its exports. On the other hand the United States absorb about 55 per cent. of Brazilian exports, and only supply about 8 per cent. of its imports. France comes next in importance of Brazilian trade, for it absorbs about 10 per cent. of exports, and supplies, more or less, 16 per cent. of imports. Germany absorbs 9 per cent., and supplies 8½ per cent.

There is one curious feature of Brazilian trade that is interesting to observe—namely, that in consequence of the vast extent of coast running from north to south through so many degrees of latitude, and consequently forming immensely various zones of climate and soil, the productions of the latter are correspondingly various, therefore we have what one may call four essentially distinct commercial zones, each one with its trade and traders absolutely distinct from the other as though they were situated in so many different countries. For example, what may be designated the northern trade comprises Pará, the Liverpool of the Amazons, with the adjoining coast towns of Maranhao, Ceara, &c. Rubber, Brazil nuts, cocoa, medicinal herbs, sugar, and cotton are the main supplies. The second group is Pernambuco and Bahia, with their adjoining ports. Sugar, cotton, and tobacco are here the main exports. At Rio and Santos, coffee is king. Down south, at Rio Grande, hides, horns, grease, horse hair, and other products of pastoral regions are the main supplies. I believe there are no firms of English merchants other than commission merchants whose trade embraces all of these four sections of Brazilian trade. I mention this because many an investor in Brazilian enterprises may seek the opinion of some merchant who has long resided in of one these centres. Now, no matter how that merchant has studied the subject of Brazil, he cannot, I believe, avoid being biassed in his opinion of it by the prosperity or otherwise of his particular branch of Brazilian trade, such as rubber, sugar, coffee, cotton, and hides and tallow, and be strongly indisposed to consider the general aspects of the vast region as a whole with all its immensely varying elements of progress and prosperity in the near future.

The statements in the Table will serve to convey an idea of the magnitude of the commercial and industrial operations of native enterprise in a land where but a generation ago such a thing as native enterprise, other than in that of agriculture, had almost ceased.

The figures I have given in round numbers, and are equivalent to the par value of the milreis. The sum of £17,290,000 was subscribed and paid in Rio de Janeiro during the year 1889. There has also been a very considerable amount of capital raised in other parts of the country, the particulars of which are not yet attainable.

Increase of capital of old companies, and raising of capital of new companies, in Rio de Janeiro during the year 1889:—

	New Nominal Capital.	Capital Paid Up.
	£	£
In 25 local banking companies	36,500,000	5,830,000
In 13 country „ „	7,312,000	1,457,000
In 6 other country „ „	not known	not known
In 31 local mills and factories	2,390,000	925,000
In 13 railways and tramways	9,100,000	6,898,000
In 16 miscellaneous companies ...	3,645,000	2,180,000
Total......	58,947,000	17,290,000

The following loans were also negotiated in Rio during the past year:—

1 General Government 4 per cent loan	£12,340,000
1 State 5 per cent. loan..............	182,000
10 Public Company loans at 6½ to 8 per cent..........................	742,000
Total.............	£13,194,000

The loans negotiated abroad were:—

In England for loans to Public Companies	£700,000
In England for loans to city of Rio de Janeiro	500,000
In Portugal for loans to State of Minas Goraes	787,000
In Portugal for loans to Public Companies	562,000
In France for loans to State of Bahia ..	480,000
In Germany for loans to Public Company	1,100,000
In Belgium for loans to Public Company	1,000,000
	£5,129,000

Thus, in fresh nominal capital of new and old companies and in loans the city of Rio de Janeiro, in one year only has subscribed the enormous sum total equal to £72,141,000. The fact speaks for itself as to the progress of the country, especially as at the end of the year 1888 the total paid up capital of all the native public companies at Rio, 83 in number, amounted to only £39,000,000.

At that time I quite anticipated the coming boom of last year; so much so that I endeavoured to organise in London an investment trust for operations in Rio.

Railway building is also now making very fair progress, and it is mainly being done by means of Brazilian engineers and Brazilian capital. Brazil commenced her first railway in 1858, namely, the Mauá line near Rio de

Janeiro, then for 14 years the English built every line in the country. In 1868 the first native Brazilian railway company was organised. In 1885 there were 4,360 miles of lines in traffic, 1,070 miles belonging to the State, 2,204 miles to native companies, and 1,086 miles to English companies. At the beginning of 1888 there were 5,275 miles of railways in traffic, 1,240 in construction, 2,113 surveyed, ready, and authorised to commence construction, 2,800 in authorised projection—total, 11,428. The actual mileage in traffic is about 6,500 miles, and in two or three years it will doubtless be doubled.

At the beginning of 1889, the lines in traffic were divided as follows:—1,251 belonged to the State, 2,844 to native companies, and 1,180 to English companies. Therefore, in the previous two years the State had opened to traffic 181 miles, the native companies 640 miles, and the English companies 94 miles. Of the railways built, in construction, and projected, 14 lines belong to the State, 2 lines to Provincial States, 30 to companies with guarantees of interest or subvention, and 37 to companies without any guarantees or subventions whatever.

FINANCES.

At the close of last year the present Minister of Finance issued a statement showing the financial position of the State up to that date, or as he described it, the legacy of Imperial rule left to the new Republic, amounting to about £120,612,000, which is an increase of £13,000,000 since the year 1886. The present amount of the debt is equal to about seven times the national revenue, and comprises all the funded and floating debt and the paper currency, but does not include the liability of the State for guaranteed interest on the capitals of railways and central sugar factories and steamship subventions, which, including the obligations of purely provincial guarantees is equal to a capital of about £25,000,000. It is this great liability to pay interest out of revenue, combined with the cost of railways and other public works undertaken by the State, that has so seriously disturbed the equilibrum of Brazilian finance for so many years past, for if it were not for this, the ordinary revenue would now be sufficient to meet ordinary expenditure.

On the other hand, had the State not assumed this liability the country would certainly not have developed to the extent it has done, for until of quite recent years national public enterprise was almost unknown. Moreover, forming part of the past annual expenditure is the cost of the railways built by the State, amounting to about £25,320,000. One of these lines, the Estrada de Ferro Central, formerly designated the Estrada de Ferro Dom Pedro Segundo, has 490 miles in traffic, and a long length still in construction. The whole expenditure on this line has been £12,634,000, and it, at times, earns as much as £840,000 per annum nett profit. Add to the cost of railways £4,000,000 paid for immigration, another £4,000,000 in water and drainage works, about £9,000,000 paid in guarantees of interest, and finally £70,000,000 for the cost of the Paraguayan War, makes a total of £112,320,000, leaving a balance of the sum total of the national debt to account for of £8,292,000, a balance which will represent the cost of the Brazilian Fleet and the relief of the famines in North Brazil.

Undoubtedly the late Imperial Government obtained a very high credit in the financial markets of the world, and also undoubtedly it will be some time before the new Republican Government will succeed in obtaining as high an estimation of their worth; yet even if the very worst was to happen, say a temporary civil war, whereby the controlling powers or strongest party would be unable to borrow on national credit except at prohibitive conditions; even so, I maintain that the country possesses so many valuable assets that they could, with comparative facility, I judge, be mortgaged at reasonable rates of interest, for it should be borne in mind that Brazil, unlike most, or nearly all, of the South American Republics, has borrowed entirely on the credit or good faith of the nation. And her public lands, her railways, water and drainage works, and the revenue of her Custom House are free from any mortgage whatever. Unfortunately, Brazil has no conveniently elastic remedy to balance the budget of a bad year like our income tax, and neither is the country directly taxed to the extent it might very well bear. For instance, a tax on land.

A land tax, the necessity of which has been strongly advocated by one of the present Ministers in his paper "O Paiz," is a tax which would not only contribute a considerable revenue to the State, but would confer on the country one of the greatest blessings its law-makers could bestow. Why I say so is because the vast majority of land at present available for immigrants in the neighbourhood of railways, and even in the distant interior, is in the ownership of a dog-in-the-manger species of proprietors, who will not part with their lands except on prohibitive terms to the would-be colonist, neither will they utilise them to the extent they might very well do. The result is, that arriving immigrants have to squat on these lands on exceedingly onerous conditions or depart to the distant interior, where, away from markets, the value of their products is consumed in a costly transport by road. The collection of a land tax would be very simple if a law was passed stating that no transfer of land would be legal unless accompanied by a receipt of payment up to date of all land taxes of the land in question. The possibility of the passing of such a law under the old regime I consider to have been hopeless, for then the great majority of the deputies and senators were great land owners, who would naturally provide for their own interests by resisting such a proposition. Under the new order of things, when every one who can read will have a vote in the election, there is some better hope of such a desirable law being passed. There are many other exceedingly interesting matters connected with the land question of Brazil, such as proved land titles, &c., but they are rather matter of Brazilian discussion than those of interest to ourselves.

The actual revenue of the country is now about £17,000,000, or more than threefold of what it was 30 years ago. About 72 per cent. of the revenue is derived from export and import dues in the ratio of 12 from the former and 60 from the latter. The State railways provide 10 per cent., general taxes, mainly on the coast, another 10 per cent. The remaining 8 per cent. is provided by stamps, post-office receipts, sale of Government properties, interest on national capital, various State institutions, telegraphs, &c.

The total of the ordinary and extraordinary expenditure of the State (last year, equal to about £19,000,000) is divided more or less as follows:—National Debt, 30 per cent.; the Army and Navy, 29 per cent.; traffic expenses and construction of State railways and public works, 29 per cent.; subvention to steamship companies and guarantees of interest to railways and sugar factories, 9 per cent. Thus leaving only 22 per cent. of the total expenditure—apart from the army and navy—for general administration purposes. The guarantees of interest paid for railways and central sugar factories absorb only about 7 per cent. of the total expenditure.

The interest of the National Debt of Brazil, as in most countries of the world, is the biggest item of expenditure, yet in the case of Brazil there is one feature which is worthy of note—namely, that the demands of the internal loans, or loans raised in the country, are more than twice the amount required to pay the interest of the foreign debt.

POPULATION.

The last census of the population made in 1872 gave a total of 9,930,478 inhabitants, consisting of 8,429,672 free inhabitants and 1,510,806 slaves. In 1888 the total population was estimated to be in round numbers 14,000,000, now, of course, all free inhabitants. The proportion of the population of the various States per square mile is as follows:—

Rio de Janeiro......	with	44·7	per square mile
Ceará...............	,,	24·2	,,
Pernambuco........	,,	22·8	,,
Alagoas............	,,	20·8	,,
Parahyba do Norte ..	,,	17·6	,,
Sergipe............	,,	14·7	,,
Rio Grande do Norte	,,	14·2	,,
Minas Geraes........	,,	13·9	,,
Sao Paulo..........	,,	11·9	,,
Bahia..............	,,	11·3	,,
Santa Catharina.....	,,	8·42	,,
Rio Grande do Sal ..	,,	7·3	,,
Espirito Santo......	,,	7·2	,,
Maranhao..........	,,	2·8	,,
Piauhy.............	,,	2·3	,,
Paraná.............	,,	2·2	,,
Pará...............	,,	·9	,,
Goyar..............	,,	·7	,,
Matto Grosso........	,,	·14	,,
Amazonas..........	,,	·10	,,

These figures are interesting and somewhat surprising, for whereas, as would be naturally expected, the most thickly populated State is that of Rio de Janeiro, the next one is that of Ceará; a State which for several years past has been subject to very severe droughts, bringing in its train, famine, pestilence, and misery. On the other hand the prosperous and progressive State of Sao Paulo shows less than half the population per square mile of that of Ceará; and Paraná, which I consider one of, if not the finest State of the Republic, so far as natural conditions of soil and climate are concerned, contains per square mile less than one-fifth of the population of Sao Paulo. Finally the vast States of Matto Grosso and Amazonas, with only 14 and 10 inhabitants respectively per 100 square miles, show that there is yet in those regions a grand territory reserved for the superabundant populations of the old world.

IMMIGRATION.

The subject of immigration naturally leads to the question—What are the chances of success that an immigrant arriving in Brazil is likely to meet with? Before I reply to that question, it is advisable to bear in mind that the term immigrant really comprises all sorts and conditions of men who arrive in any country with a view to settling in it; but in practice the application of the term is intended to denote a body of more or less impecunious individuals seeking, mainly through manual employment, for better chances of eventually securing an independence than is afforded by their own countries. I make this observation because for an entry to Brazil of a combination of capital and labour, I say, yes, by all means let it go; but to send out crowds of our labouring poor and consign them under the present order of things to the tender mercies of Brazilian land proprietors, or even to send them to some distant unsettled regions of the interior as colonists, then I say failure and misery would be the inevitable consequence. Brazil has tried over and over again to induce immigration, and has paid at various times something like £4,000,000 sterling in expenses and commissions to immigration agents.

What the Brazilian land proprietors are really anxious to obtain at present are large bodies of foreign labourers ready and willing to fill the place of the former slaves on the great coffee and other estates, and to answer this requirement I cannot see what advantage it is for a European labourer, especially a British one, to go to Brazil. But I feel assured that the Brazilians will fail to secure their object; they may pay Italians and others to go there, but they will fail to retain them long on the required conditions. But by no means do I mean to imply by these remarks that I anticipate that the great coffee, sugar, and other industries are likely to fail for want of hands. Not at all, for I feel convinced that the emancipated slaves will eventually become useful citizens; I judge by what I have lately seen in Jamaica, and by what I have seen during many years in Brazil. In the latter country the free black man (the blacker he is the better) is by a long way a far more useful citizen than the ordinary whitey-brown peasant; for in the interior, whenever I came across some rare example of thrift and industry, in nine cases out of ten it was the work of a family of negroes. The best muleteer I ever saw was a negro, my best labourers on public works were negroes, the most industrious farmers I ever met were negroes, and the most intelligent mechanic and foreman in my employ was a negro, and in many of these cases the men had once been slaves. Also, scattered all over the interior of Brazil, there is a very numerous population of mixed races, leading an almost objectless existence in providing only for the passing trifling requirements of their simple lives. It is not because they are irretreviably lazy: they are lazy, certainly, but it is mainly the result of not having any stimulus to do more than is absolutely necessary to keep body and soul together, for, often separated from a market for their produce by hundreds of miles of rough bridle paths intersected by bridgeless rivers, what inducement can a man have to produce more than he requires if he cannot dispose of it at a fairly remunerative profit. When, years ago, I went amongst these country people on surveying expeditions with money in my pocket to pay for their service, I obtained all the men I wanted for 2s. a day for long and arduous work in pestiferous forest and swamp, or under the scorching rays of the sun on the rivers; on the latter I have got out of my men at times 16 hours of heavy labour at the paddle or pole.

These are the labourers Brazil requires, they only require gathering together in progressive regions where they can obtain a due reward for their services. As a matter of fact, this is now really occurring, for the steamers on the Amazons now afford a ready transit to thousands of emigrants from the neighbouring drought-stricken State of Ceará to gather the wild products of the virgin forests of the most distant recesses of the Amazons, in regions which, without this means of rapid transit, would have remained inutilised for generations to come. Again, in Sao Paulo, the marvellous increase in the traffic of the Sao Paulo railway shows, without quoting any statistics, how the production of that State has increased, certainly far in excess of any increase of the former population or of the arrival of the actual number of immigrants. The result is entirely due to the 81 miles of the English railway having been extended inland in various directions and by various companies for 1,711 miles, and opening of some hundreds of miles of river navigation, a work which has been done by native enterprise and native capital, and has afforded a means to bring to a market the products of old and new regions of the State, which otherwise would have remained in the lifeless state of stagnation still common to the more inland railwayless regions of the interior. The construction of these railways has also afforded lucrative employment to thousands of Italian immigrants, labourers, and artisans, and to thousands of the peasant folks of Sao Paulo and the adjoining States, who will doubtless eventually become permanent residents in these newly developed regions.

I might enumerate many other examples, not only of what great developments of old and new regions has been made by creating railway and fluvial communications in other States of the Republic, but also what is likely to occur in the still further extensions of those same means of transport, but time will not permit, and I must hurry on with my subject.

The last year or two has seen a remarkable increase in the number of immigrants seeking a home in Brazil, mainly resulting from the abolition of slavery on 13th May, 1888, for from 1877 to end of 1887 the annual average was 27,000 arrivals, but in the year 1888 Rio and Santos alone received 132,000, whereas last year the number decreased to 65,000, chiefly Italians.

To show what rich natural wealth bountiful Brazil offers to those who care to gather it, I must refer to the wonderful progress made in the regions of the Amazons since 1867, when that great fluvial highway to the heart of the Continent was made free to the ships of all nations. Then the annual output of india-rubber was only 3,000 tons per year; now it is close upon 16,000, and all this, with the major part of all the other Amazonian exports, are gathered from the wilds of the vast forests of that immense region. These wild products of the forest, such as rubber, Brazil nuts, and medicinal herbs of various kinds, are so valuable, and exported in such quantities, that the value of the exports of the State of Pará are equal to £7 17s. 4d. per inhabitant per annum. Those of the State of Amazons are equal to £7 5s.; whereas those of the Argentine Republic are but £4 10s., and those of the United States of America, £3 3s. 10d. Yet with all inducements to collect this natural vegetable wealth, the region of the Amazonas is no place for the European labourer, for manual labour can only be done by negroes and coolies, or the Indian inhabitants of those regions, or by the mixed native races now emigrating to the Amazons from one of the most populous States of Brazil, that of Ceará. But in the south of Brazil, in the lovely climate and splendid soil of the prarie lands and *Araucaria* pine forests of Paraná and of Rio Graude do Sul, there is ample space and opportunities for a long and steady flow of immigrants; it being always, however, borne in mind that they must not all be impecunious immigrants, but must be accompanied by capital likewise, as has invariably been the case in the founding of our own colonies.

I have mentioned that the Amazons is not fitted for European labour; at the same time, it should be borne in mind that I do not by any means condemn it as a field of enterprise for capitalists; on the contrary, I know of no region of the world that offers such great prospects of lucrative employment as does this valley of the Amazons. For, if the bountiful plenitude of the wild nature of these regions is sufficient to return, to those who choose to stretch out a hand to gather her fruits, a sum per head of inhabitants more than double what the great industrial and agricultural resources of the United States of America produces, is it not wonderful to think what those same Amazonian regions would do if their indigenous products were cultivated, and thereby create a tremendous saving of the time and expense now wasted by the collectors in travelling, as they do, such great distances to and from their place of operations, and even in the forests, wasting time in searching for their particular requirements.

India-rubber trees, for example, if properly cultivated, would, at the end of ten years, return 150 per cent. on the capital expended on their plantation, as I will endeavour to show. In the States of Pará and Amazonas, under the law 1147 of the 27 Sep. 1860, a grant of about 2,500 acres of land may be obtained on the condition that it is planted with rubber trees. Suppose, for example, that only 1,000 acres were put under cultivation. The trees would have to be planted 35 feet apart, there would consequently be 35 trees per acre, or a total of 35,000 trees. Six years after planting the trees commence to yield, but ten years are necessary to enable them to attain full maturity. Then a minimum average of 16 lbs. of sap per annum could be extracted from every tree without the slightest detriment to its well being. The gross yield would therefore be 560,000 lbs. of rubber, or 250 tons of the value of £70,000. One man can in one day collect in such a rubber plantation 50 lbs. of sap and turn it into rubber, consequently the force required would be 100 men working

112 days. Ten shillings per man per day would command the services of any number of natives fitted for the work; the cost of gathering would therefore be £5,600, and with management and all expenses say in round numbers £10,000, leaving a profit of £60,000 per annum. The cost of clearing land and planting it with trees, erecting houses, sheds, &c., should not exceed £30,000. Therefore £40,000 would be ample capital, the return on which at the end of ten years should be 150 per cent. This might be still further increased by planting cocoa in the intervals between the trees. Cocoa commences to produce at the end of four years, but requires nine to reach maturity, when, from statistics sent me by a planter in Pernambuco, and obtained from his actual experience, the net profit of a cocoa plantation yields 100 per cent. of the amount of capital employed.

From the above figures relating to the cultivation of india-rubber trees, it will be found that 64,000 acres planted with those trees would be necessary to equal the present rubber supply of the Amazons, but in the wild forest where the trees are few and far between, the enormous area over which the collectors have to roam seems almost incredible. And as they cannot there gather more than an average of 20 lbs. of sap per day, the number of men employed, allowing 10 per cent. for death or sickness, must be about 22,000 fully occupied in the forest for a period of ninety days.

This plan of rubber cultivation is not only desirable but it will soon be absolutely imperative, for rubber is becoming every year more and more utilised in the ever-growing demands of new industries, The Amazons is the great supplier of the rubber market, but every year the gangs of rubber gatherers have to proceed further and further in search of the valuable sap, leaving almost invariably behind them a track of exhausted rubber trees. In fact the present crop is reported to be 1,000 tons short. I do not expect that these hints of mine will lead to any action, any more than the exertions I made in 1876 to induce English capitalists to establish cotton mills in Brazil, and although I then showed an immediate profit of 50 per cent. per annum, I could show no Government concession for a monopoly or a guarantee of interest; my proposals were therefore received as though I was suggesting cotton mills for the moon. Then there were only six mills in the country, now there are over 100, and all, without exception, are most extremely successful native enterprises, paid for with native capital, and worked with native labour.

The fact is Brazil abounds with extraordinary opportunities for a profitable employment of British capital, not for a contractor's job or for company mongering, for then the inevitable result ensues, as in the case of the central sugar factories, and I make this assertion strongly and emphatically in face of the fact of there having been already so many disastrous consequences to the investor in British enterprises in Brazil. The concession business is largely answerable for so many fiascos, although I am quite prepared to admit that without the hitherto indispensable concession it would be vain to look for subscription to capital from the public; besides, the concession, which costs comparatively little to obtain, constitutes something to sell at a good round consideration; the financier then takes his share of the spoil, and the contractor the rest, leaving the company generally without working capital and in the direction of a board of gentlemen, well meaning and of good social standing as a rule, but in nine cases out of ten they are equally ignorant of the idiosyncrases of Brazil and of the nature of the business they are set to manage. The dismal fate of the various central sugar factory companies is a case in point, which fully endorses my assertion, for when other absolutely similar sugar factory concessions have been taken up and managed by Brazilians, those enterprises show not perhaps a brilliant success. but certainly a very fair state of prosperity in remarkable contrast to the English companies.

The position of many of the English railway companies in Brazil could, I feel sure, be vastly improved were a little more vigour and enterprise introduced into their management by directors possessing the necessary knowledge of the conditions of the local Brazilian requirements, and of the character of the industry they directed. Foresight also appears to be conspicuous by its absence amongst not only the directors but the foreign managers of English railways in Brazil, otherwise the present great and extremely profitable railway system of the Sao Paulo might have remained in the hands of the Sao Paulo Railway Company. They once had the right to extend that line where the Brazilians have since constructed over 1,000 miles, but the permission to extend their line was declined with thanks.

I am afraid I have rather drifted away from the subject of immigration, but one thing leads to another, thus I am now induced to make a few remarks on the neglected mineral wealth of Brazil, for I feel assured that at no distant date it will be the means of attracting a rush of immigrants.

In the Argentine Republic, it is wonderful to note what rapid progress that country has made of late years, simply by means of immigrants, who have come only by reason of the facilities the country can offer for agricultural and pastoral purposes; but when, in addition to these advantages, Brazil becomes known to possess a still rich virgin gold and diamond region, it does not require much imagination to realise the huge strides the prosperity of the country must necessarily make when its vast interior is only, even in a small fraction of it, made productive by offering to the ever ready adventurers of the world the irresistible attraction of another South Africa, and make it in the near future another California or Australia.

A few statements gathered from authentic records of the past mining era in Brazil are really startling; for example, in the one year, 1778, the diamonds remitted to the coast of Lisbon amounted to 65,759 carats. In 1792 the gold registered in Rio de Janeiro was 360,000 lbs. in weight. The amounts of the royalty, or one-fifth of the gold produce of the mines of Minas Geraes actually received by the then colonial Government was, more or less, £8,000,000 sterling; yet in consequence of the enormous extent to which contraband mining was known to have been carried on, it is believed that the Government did not receive more than one-twentieth part of its due. If that be so, the total gold output of Minas Geraes must have been £160,000,000 sterling, and quite recent researches amongst old archives put the amount at £200,000,000.

Startling as these figures appear, credence is possible when one learns from known facts what was actually done in some places. About the middle of the 18th century, at a place called Coral, or Curral, within the area of a square mile, and in one year, 4,800 lbs. weight were panned from placers. At Ouro Podre, in Goyaz, a party of contraband miners collected in one night 96 lbs. weight of gold. The royalty or fifth received in 1753 by the State collections at Villa Boa, Goyaz, was 8,714 lbs. and from Sao Feliz in North Goyaz was 3,102 lbs. weight. The mystery why this once enormously lucrative industry has so utterly ceased is quite capable of solution, but as it would take too much time to explain, I must pass it over and ask you to believe me when I say that the industry did once exist to the extent I have endeavoured to convey by the figures I have quoted, and that a resuscitation of the industry is quite possible, nay, most probable. I do not, however, look for it in the old abandoned mining regions, but rather in regions where gold and diamonds have been found but little worked—namely, in the table lands of Northern Matto Grosso and amongst the mountains and plains of Southern Goyaz; regions once dominated by hordes of hostile Indians and buried deep in the heart of the continent, are now within a measurable distance of the present end of the Mogyana Railway, which year by year is extending in the direction of these regions.

In this cursory synoptical survey of Brazilian affairs there are necessarily numerous other items of importance to the student of the present position of Brazil, which, for want of time, I must omit, but for anyone who wishes to know more of the subject I cannot do better than refer him to an excellent and exhaustive treatise on the country published last year in French by Charles Delagrave, in Paris, and also, with your kind permission, to my own publications relating to Brazil.

However, I trust that I have been sufficiently lucid in my treatment of the various subjects I have dealt with, to enable you to gather some sound facts on which to form some reasonable conjectures of the prospects of Brazil in the near future. My own impression is that we shall speedily see Brazil emerge from its present state of political chaos, a solid united nation of confederated interests and States, and that a few years only will probably see it advance with such strides of progress, and attain such a degree of prosperity, that at the moment is hardly conceivable. I may be wrong, but such at least is my earnest conviction and, I may say, desire for a country and people among whom I so long sojourned.

DISCUSSION.

Mr. W. Martineau, having lived some years in Brazil, and knowing something of the country, desired to thank Mr. Wells for his very interesting paper. His own knowledge was chiefly confined to railway matters, and on that point he concurred in thinking that the era of concessions had come to an end, and would hardly be renewed, though the present Government would no doubt respect those already granted. For the future railways must depend on the resources of the country for their support, and not look to the overstrained treasury of the country. With regard to the recent political changes, he could only hope that wise men might be found to direct affairs; if so, no doubt Brazil would prosper very rapidly. Any ultra-revolutionary movement, or pushing forward of Socialistic doctrines, of which there seemed to have been some danger, would only retard that progress; but, recognising as he did the commercial instinct of the Portuguese race, he thought they were not likely to repeat the errors which had been committed in former years by the military adventurers who dominated most of the Spanish Republics. Brazil, with its immense territory, and undoubtedly healthy climate in the interior (though it bore a bad reputation on the coast), when it was better known, and when more reasonable views were entertained by the landowners of these districts, ought to become a great field for emigration for the whole world; for no nation that he knew of possessed such a vast extent of cultivable habitable country.

Mr. FREDERICK YOULE said it was some 50 years since he first visited Brazil, at which time it was in a very different condition to what it now was. The habits of the people were very simple, and there being no steam communication with Europe until about the year 1850, when the Royal Mail Steam Company's service commenced, few of the Portuguese who went there ever thought of returning home. Since the era of steam there had been a great change in this respect, and the Portuguese return to Europe, some to remain, and withdrawing large amounts of capital with them from the country. In his opinion it was a great misfortune that so small a country as Portugal, containing but 4,000,000 of inhabitants, should have been, for the past 300 years, almost the only one to furnish emigrants for Brazil. He did not think there was much chance for English emigrants, who had the United States and our own colonies, which offered them greater advantages. The change in government which had occurred lately had taken everyone by surprise, and although many expected it upon the demise of the Emperor, none looked for so sudden a change. He had faith in the future, and trusted the good sense of the people would place such men at the head of affairs, after the elections in September, as would insure the prosperity of the country.

Dr. SYMES THOMPSON said it had occurred to him that Mr. Wells might possibly give the profession he represented some useful information with regard to Brazil, as a place to which they might send those suffering from illness with a prospect of benefit. In these days great importance was attached to elevation, and he could not but think that there must be, in many of the regions referred to, high table-lands of great salubrity and dryness, well suited to those suffering from chronic illness. The voyage to Pernambuco or Rio de Janeiro was now becoming very popular, many taking it for enjoyment as much as for health, and it occurred to him that there might be localities where such persons might settle, and not only gain health for themselves but assist in the development of the country to which they would owe so much.

Mr. A. MONTEFIORE said he knew very little of Brazil, having only visited it as a bird of passage; but he had read in Mr. Wells' interesting book, "The Voice of Urbano," a very graphic description of the indiarubber industry in the valley of the Amazon, and he should like to ask how far that industry was controlled or assisted by British capital?

The CHAIRMAN said that Section of the Society was mainly concerned in practical and commercial questions, and the one which was most prominently brought forward in this paper was this:—What was going to happen next? Would Brazil settle down peaceably under the new order of things, or what would be the result? and the answer not unnaturally was that no one could tell. Mr. Youle, an old friend of Brazil, who, like himself, had seen the first Emperor, Dom Pedro I. as well as the last, had expressed his good wishes for the future of the country, and in those sentiments they would all agree; but the practical question was, would England go on contributing capital for the development of its industries. There had been too much attention bestowed on the mere question of the form of government, whether a monarchical or a republican was the best for Brazil. They had been told on the one side that Brazil was far superior to Chili or the other American republics by the mere fact of being a monarchy; and now, on the other hand, a good many were disposed to look with favour on the future of Brazil because it had adopted the republican form of government, while some mistrusted it on that very ground. In reality, standing aside, as they were bound to do there, from politics, he might say that it mattered little what the form of government was, because the elements of monarchy and of a republic must in the nature of things be the same. If they referred to the fathers of political science in Greece, or to more modern authorities, they would find the same thing — that the form mattered very little. There was this, however, with regard to the monarchy, that the late Emperor was a man of most distinguished character, and one who had done much for the development of the country. Carrying one's memory back to those times of which Mr. Youle had spoken, the empire was created to save the country from internecine war, there being such differences and conflicts of opinion as very nearly split the country up into a number of small states; and both the voice of Brazil and of Europe concurred in payng the highest tribute to the high character of the last Emperor. To his mind, one thing with which he had been reproached, the small military force, was one of the greatest proofs of the ability with which he conducted the government of so large a country and having so varied a population. At the time of the revolution the army only numbered 20,000; and where in Europe could you find a state with so large a population as that of Brazil, which was able to conduct its affairs so successfully with so small an army? He considered that one of the greatest tributes to the late Emperor. He was a man who would have done honour to the title of chief magistrate, and if necessary he would have exposed his own life in the revolution. It was, however, impossible. Events had been taking place for years which made it impracticable to make any defence against what was purely a military revolt. It burst forth on a sudden, though it originated some time before, as such military movements did. It was the old story; it did not arise from pure political and patriotic causes, there was a woman in the case; intrigues arose; a movement was made to surprise the Minister of War, the students turned out, and by them the Republic was proclaimed. But looking at the incidents altogether, one could not but hesitate before forming any decided opinion as to the stability of the Government, the result of a military revolt, which had now taken the shape of a usurpation. The parties in possession of power were making laws without legislative power, when they ought to have called together a constituent assembly, which could alone give a legitimate form to the Government. The condition of the country did not depend on political institutions, but on the industrial products and on the character of the population. The Federal Republic of the United States was formed by men of great experience and ability, founded on the inheritance they had derived from their ancestors in this country, and it had lasted one hundred years. In other countries the same thing had been attempted without attaining the same stability, change after change having taken place. One thing greatly wanted in Brazil was good political education, founded on such models as those of the United States rather than on these which seemed to be influencing the present Provisional Government, the ideas of French writers without practical experience; and already laws had been brought forward which had suggested such cautions as Mr. Youle had very wisely given. It was impossible to conceal from oneself that there were circumstances which might cause an interference with the present state of affairs, for a military insurrection, in the nature of things, provoked other military insurrections. The future would depend in a great degree, not on these political circumstances but on the continuance of the aid which had been given in the past by English enterprise, which had really caused the great development not only of Brazil but of all other countries in South America. Would the present or the future Government exhibit the same good disposition towards English enterprise as was manifested by the late Emperor? That was the important question. Unfortunately, before the late revolution, the Government thought itself independent of the aid of English capitalists. The people had to a certain degree become independent; they had reached the stage which Chili had of being able to make their own railways, and they thought the time had come to throw off their English friends; and very troublesome questions had arisen with them on more than one point. One of the examples which had been given of the development of capital was the loan raised in Portugal for the State of Minas Geraes, and he believed that had fallen to the ground on account of the opposition of an English company, the Minas Central Railway Company, the concession for which had been declared abolished by the provincial Government of Minas. Thereupon her Majesty's Government thought it right to interfere, because the Imperial Government denied justice when an appeal was made to the Council of State. If the Government of the United States of Brazil would go on in concert, and keep up the credit of the country as the Emperor did, they would have abundant means of developing the country to a degree far beyond what the Imperial Government effected. As Mr. Martineau had said, there was scope for everything. Railways were yet in their infancy, and when agriculture, mining, and other industries were developed, immensely increased means of communication would be required. It was perfectly notorious that, down to 1825, the production of gold in Brazil, and diamonds also, was on a very large scale; and there could be no doubt that when operations could be resumed there would be as large a production as before. He concluded by proposing a cordial vote of thanks to Mr. Wells, which was carried unanimously.

Mr. WELLS, in reply to Dr. Symes Thompson, said the highlands, south of the latitude of 20°, were some of the healthiest and driest regions of the globe. The province of Paraná especially was remarkably healthy, and had an elevation of 2,000 to 3,000 feet above the sea. The majority of the districts coloured dark green on the map were covered with *Araucaria* pine forests. In the north, again, there was Ceará, near the equator, where consumptive people were sent from Pernambuco for the sake of the extremely dry climate, though it was very hot. When he was in Rio, in 1873, there arrived there an invalid in an advanced stage of chronic asthma—so bad that on the voyage out he was unable to lie down in bed and had to sleep in a chair. He (the invalid) asked leave to join the surveying party, and was allowed to do so after it had been explained to him that he would have to rough it. He did so, and accompanied them for two years through the interior, sleeping in tents or out on the grass, and when he last saw him he was comparatively well. In reply to Mr. Montefiore, he did not think a penny of English capital was employed in the cultivation of the india-rubber trees, though, as he had shown, it would be lucrative; very little planting was indulged in by the natives; the india-rubber was nearly all collected from the wild trees, and they had to go further and further afield for it. English capital was employed in transporting it by the Amazon Steam Navigation Company, which was in a very prosperous condition, and would soon be still more so.

APPLIED ART SECTION.

Tuesday, March 25, 1890; WILLIAM SIMPSON in the chair.

The paper read was "Engraving in Wood; Old and New," by W. J. LINTON.

The report of the meeting will appear in the next number of the *Journal.*

SIXTEENTH ORDINARY MEETING.

Wednesday, March 26th, 1890; Colonel Sir NIGEL KINGSCOTE, K.C.B., in the chair.

The following candidates were proposed for election as members of the Society:—

Barry, John Wolfe, 23, Delahay-street, S.W.
Bateman, James, "Pinetown," Natal, South Africa.
Jones, Arthur L., 45, Hillside-road, Stamford-hill, W.
Woollett, Captain William Charles, Royal Dockyard, Woolwich, S.E.
Yardley, Robert Blake, 6, Crown-office-row, Temple, E.C.

The following candidates were balloted for and duly elected members of the Society:—

Barron, Frederick C., Nervion, Beckenham-grove, Shortlands, Kent.
Chapman, Frank, 5, Tyrwhitt-road, Brockley, S.E.
Clirehugh, Stamford Vair, 14, Ladbroke-terrace, W.
Day, William J., 8, Sydney-villas, Richmond, Surrey.
Guy, Charles Williams, Laurel-bank, Anerley, S.E.
Lewis, William Bourne, 15, Victoria-street, S.W.
Rainger, Henry René. 31, Heathfield-gardens, Chiswick.
Rivington, Charles Robert, Stationers'-hall, E.C., Fenchurch-buildings, E.C., and 74, Elm-park-gardens, S.W.
Tyrrell, Avery, Berkin-manor, Horton, Slough.

The paper read was—

CARRIAGE-BUILDING AND STREET TRAFFIC IN ENGLAND AND FRANCE.

By GEORGE N. HOOPER.

In the year 1855, the Council of the Society of Arts requested me to draw up a report on the carriages of various nations then collected at the first French Industrial Exhibition, and it was read in this room, when the late Marquis of Lansdowne, a connoisseur of carriages, and a member of the carriage jury, presided.

After an interval of 34 years your Council has again done me the honour of inviting me to read another paper relating to the Universal Exhibition recently held in Paris. In the interval since 1855 it has fallen to my lot to draw up three of the official jury reports, besides several others, to place on record the leading facts connected with the carriages at each of the great exhibitions that have from time to time taken place, besides one of a specially technical character to the students of the carriage class held at the Polytechnic Institution in Regent-street on Monday, December 9th last, on the subject we are to consider this evening.

RETROSPECTIVE EXHIBITION OF ROAD CARRIAGES AT PARIS.

Let me remind you that the carriage department of the Paris Universal Exhibition of 1889 had two separate and distinct sections—one "the retrospective exhibition of the methods of locomotion by land before the introduction of railways" collected in the building devoted to the liberal arts; the other, "modern carriages for private and public use," exhibited in the building devoted to manufactures. The former consisted of drawings, engravings, lithographs, photographs, models of carriages, a few carriages of various types and dates, but very unrepresentative of the carriages generally in use on the roads of, say, 40, 50, or 100 years ago. Such articles are bulky and perishable, and nearly all are destroyed as they become obsolete.

It seems strange that it should have been France and not England that proposed and carried out a retrospective exhibition, for it was England that in modern times first set about improving her roads, and so encouraged the building of improved carriages to use them; and it was England that established the first railway and locomotive.

But although this retrospective exhibition was not held in the country that has effected most towards the development of locomotion, it was necessarily England that supplied the most important and interesting series of illustrations of mediæval and modern carriages, including the collections of the Institute of British Carriage Manufacturers, the London Guild of Coachmakers, the collection of my own firm and those of Messrs. Atkinson and

Philipson, and of Mr. Barr. These included photographs of most of the existing State carriages of the sovereigns of Europe, lithographs of the State carriages of some of the Kings of France; German, Russian, and other road carriages, and a large series illustrating the public carriages in use in England before railway travelling became general.

So pleased was M. Bixio with the collection made in London, that at his urgent request it was greatly extended. The French contributions were on a smaller scale. There were a few models and several carriages illustrating carriages of State or for ordinary use.

Among the English engravings were three of a chariot, a barouchette, and a high phaeton, bearing the date 1819, and showing the carriages fitted with Ackerman's pivoted axles. In the modern French carriage department was exhibited a drag fitted with similar axles; and the exhibitor was awarded a Grand Prix. Thus an English invention has been reproduced in another country, after being unused in our own since it was first brought into notice 70 years ago.

It is to be regretted that of the State carriages, lent by Spanish grandees to the Barcelona Exhibition of 1888, not one was shown at the Paris Exhibition last year. These carriages admirably illustrated the Court equipages of two centuries ago.

While inspecting the retrospective exhibition of carriages, a visitor at my side remarked to a friend, "Well, M. Bixio has succeeded in making a very fine collection,"—but it was a London working committee that so greatly aided the organisation of so large, illustrative, and complete a collection.

My experience, which embraces the whole of the exhibition era, begun in 1851, including the recent Paris Exhibition, enables me to compare the condition of the carriage industry in France at succeeding periods, and also to compare the French manufactures past and present, with our own. If the originating power is with us, the organising and developing power is with them. Our neighbours, ever since 1851, have displayed an aptitude in seizing upon the advantages of exhibitions, which, by contrast, brings out a certain lack of that aptitude in ourselves. There can, at any rate, be no question that, so far as carriages are concerned, their system of fostering and favouring native manufactures, allied with a keen perception of the advantages of exhibitions as world markets and as national advertisements, have greatly strengthened them as competitors for the world's trade in road vehicles. Our own country, we must confess, has not fully grasped the nature of the system which it inaugurated. An international exhibition is essentially an international competition, and with a perspicuous people like the French, a recognition of this fact involves the interest and action of the Government. Unfortunately for British industry, that inequality of conditions between us and our foreign competitors which was necessarily brought about by our free trade policy, has not hitherto been mitigated by the vigilance of any bureau of commerce. There is a want of perception of what is logically involved in a great exhibition. In Paris recently all the best positions were appropriated for the native carriage-builders, and consequently these builders felt encouraged to incur the expenses of effective display. We cannot blame our neighbours for making the best of their opportunities, however we may lament our own want of address. They would not, probably, have thus practically excluded us from the contest had they not known from experience that we should not retaliate. Perhaps our unfavourable position in international competitions of this kind may be due to insular pride, or shall we even say to that magnaminity which is akin to weakness? But surely, unless we can improve our commercial organisation, we can only hope that the nations of the world will give up holding international exhibitions, which we see can be manipulated into national advertisements.

The modern French carriages were exhibited under the most favourable conditions of light, cleanliness, and suitable surroundings, as is always arranged by their active and intelligent syndicate chamber. Each of the chief houses had space allotted for five carriages, while others of less importance had space for three, two, and one each. I was told that a joint purse had been formed to provide suitable fittings, such as floor-cloth of quiet colour and pattern; posts and velvet ropes, and brass fittings; roof decorations, &c., which, when apportioned, cost the exhibitors about £20 per carriage.

POLICY OF THE STATE AS REGARDS INTERNATIONAL EXHIBITIONS.

This may be a proper place to draw attention to the fact that at such exhibitions as I refer to, British exhibitors do not stand on such favourable conditions as is the case with foreigners, whose Governments make money grants, and facilitate good organisation, in order to place the products of their manufacturers on favourable conditions before the large number of visitors who flock to such great international exhibitions; and where it is of importance that a good impression should be produced by British goods, when exhibited at the same place as those produced by other competitors for the world's trade.

The recent Paris Exhibition had attached to it certain commemorative sentiments that were not quite in accord with those of several Governments—our own included—but where such political or national recollections do not clash with those of our country, it seems as if some Government recognition and grant—perhaps proportioned to the contributions of exhibitors—might with advantage be made, and the prestige and authority of the Government exerted to attract the best exhibits of the best British manufacturers, so as to make a favourable impression on visitors. On this point I will only venture to offer an opinion on the particular exhibits we are considering this evening. It was noticed by experts that all the manufacturers of the best French carriages, as well as of the materials made for French carriage manufactures, were exhibitors, to the absolute exclusion of makers of low qualities. The consequence of this is that visitors have formed a very favourable opinion of what they saw in the French carriage department, which has been of advantage to the whole carriage industry of the country, and will tend to promote and extend French trade.

These great international exhibitions are the modern counterparts of the great fairs of the Middle Ages, and offer opportunities to active and enterprising manufacturers which they cannot afford to ignore, costly as they find them. In England, firms with old-established connections formerly carried more importance and prestige with buyers than at present. The active and rapid modern systems of business unsettle old connections, and younger men come to the front who court the custom of a younger generation of buyers in a different way. At such exhibitions, manufacturers are brought into actual contact with the buyers, whose wants they can exactly ascertain for themselves, and thus open channels of trade which may tend to considerable results.

Those persons who have critically examined the carriages at the great international exhibitions of the last 40 years must have been struck with the changes, more or less rapid, but none the less continuous, that have taken place in the character of the exhibits, and their reflection of the customs, uses, requirements, and fashions of the times of successive periods.

EXHIBITS OF FRENCH AND OTHER MODERN ROAD CARRIAGES.

In the early exhibitions there were specimens of court and dress carriages, such as are only used by princes and nobles. Only a trace of such carriages was to be found in the Exhibition at Paris. This element was contributed by Italy, and though not highly decorated, similar carriages were common enough in the great capitals of Europe forty years ago. In the early exhibitions, again, carriages of fantastic and extravagant outline and finish were to be found, but such is scarcely the case now; and one contributor who showed a carriage that can be changed into fourteen different forms, was not encouraged by the carriage jury, and he will probably turn his ingenuity to better account in future, for it is likely that of the fourteen different changes he can effect, one only may be satisfactory. Only one barouche and one D'Orsay chariot were shown by Paris firms. Such carriages are disappearing from other capital cities besides London, and will probably, in the future, only be retained in the establishments of kings, princes, and great nobles. In these latter days, most manufacturers, even of carriages, have to appeal to a wider circle of buyers than formerly, and so do not display products for which there is but a very limited demand.

Although in the great Exhibitions of London in 1851, and Paris, 1855, not a single example of a "drag" or four-in-hand coach was shown (the advent of railways having but recently thrown similar passenger carriages out of use), now there were several examples shown in the French and Belgian departments. About twenty years ago, several noblemen and their friends formed a new Four-in-Hand Club, somewhat on the lines of former clubs that had died out, and so revived a taste that had a strong hold on the upper classes in England. The popular enthusiasm and excitement created by their periodical meets in Hyde-park, together with the establishment of the Coaching Club and of public four-horse passenger coaches on some of the roads round London, afforded so much pleasure to themselves and their friends (ladies included), that foreigners thought there must be something in it, tried it, liked it, and carried the fashion to their own countries and homes, where drags are now to be seen, in Paris, Rome, Brussels, Naples, Madrid, New York, and San Francisco.

The French and Belgian coaches exhibited at Paris last year were all of English type, following English outlines, proportions, style, construction, and equipments. But however much the French makers have benefited by English example, one peculiarity may be noticed, and that is the very liberal use of pig-skin in and on these carriages, wherever it can be applied, one maker having gone so far as to line the entire interior of his drag with this material.

According to the French system, by Government aid and influence, the oldest and best established producers are easily induced to exhibit. These firms of carriage builders know that their reputation and goods will be in the keeping of a superior and respected authority, which is careful to maintain the national prestige, and they lavish energy, skill, and money upon the occasion. Hence their contributions to the Exhibition represent the highest possibilities of the craft in their country, and the *éclat* which is won by a few eminent firms spreads over the whole French industry of carriage building. The stimulus to trade which is thus brought about is a national benefit, and a testimony to the soundness of policy which unites commerce, the foundation of modern society, with government.

One of the most pressing observations suggested by the recent Exhibition is our want in this country of a Minister of Commerce or Secretary of State for Commerce. Exhibitions should be to us what the great fairs were to mediæval Europe, with this difference, that with our unrivalled means of communication and locomotion by sea and land, it is not so much the actual buying and selling there and then that is of importance, but the credit and reputation which will attract custom. In other words, it is a question of guarding our national prosperity, and concerns us all alike.

Perhaps no one will dissent from the simple proposition that the prosperity and prestige of any industry is a matter of national concern, inasmuch as it affects, more or less directly, the prosperity of all. This logically involves, whether we recognise it as the French do, or continue to ignore it, that every industry should be a subject of State solicitude. Our free-trade policy binds us to see that competition shall have free and fair play, otherwise it is no policy at all, but a surrendering of policy and everything else to chance and the chapter of accidents. For instance, the absence of British carriages of high class from the recent Exhibition was to be regretted; but it followed from our system, or rather want of any system, just as surely as the favourable conditions which they enjoyed followed from the system logically and consistently pursued by our neighbours in respect of all international exhibitions. Let me suggest this contrast to you. If we hold an international exhibition here, our neighbours send their carriages over duty free; they do not find their exhibits debarred from the best positions; they have ample means and opportunities to study all our improvements. Now, if an exhibition is held in Paris, the first thing we English carriage builders call to mind is the high duty which will be levied on our goods under the French tariff; then we call to mind the remote and unsuitable position to which our exhibits were relegated in the Paris Exhibition of 1878; then we remember that our neighbours have copied many of our improvements, and while we feel no great eagerness to show them our novelties, our experience induces the conviction that we should not, under such unfavourable conditions extend business relations. The contrast is complete, and it justifies me in saying that if the unfavourable representation of British carriage builders last year is, in its effects, of national concern, it is also of national concern that there shall be some authority able to vindicate British commercial interests when they are put upon their trial in these great international contests.

Owing to the increasing trade with the Republican States of North and South America, a demand seems to have arisen for adaptations of such carriages for use in climates far hotter than our own; the adaptations are effected without much altering the construction, by making the coaches without side top panels—thus providing plenty of fresh air for those sitting in the body and at the same time shelter from the hot rays of the sun. The usual proportions have been greatly exaggerated in the case of a carriage of the kind made for South America, and probably to be used on bad roads with six or eight horses. There may be good reasons for making such carriages with massive wheels, axles, and springs, as with weighty under works the carriage is less likely to be upset on bad roads, than with the lighter ones generally used on well-kept roads in

Europe, and, in addition, it may be more convenient to travel in large parties. One French builder is now making drags for driving four small horses, of lighter construction and measurements, suspended on elliptic springs, and he says he has had a good sale for them. Many such were made in England 20 or 30 years ago.

I should not here omit to draw your attention to the drag I referred to when describing the illustrations on the retrospective exhibits, with pivoted front axles, invented and patented in England by Ackerman more than 70 years ago; it has, with other carriages, secured the maker a *grand prix*, but whether the modern adaptation will, in use, be an improvement and success remains to be proved. Frenchmen speak on the subject with reserve; the idea is new to them; but I think we should have heard more of its merits in England if it were practical and useful.

There was an increase in the number of brakes, *char-à-bancs*, and road phaetons, made specially for the owner's own driving in the country, some to carry gentlemen only, others to carry ladies as well as gentlemen; most of them are well-proportioned, and afford convenient access, but others, although somewhat pleasing to the eye, are rather heavy-looking and difficult of access. They have a more sturdy and sporting look than formerly, and are not provided with such elaborately luxurious squabbing and cushions as those exhibited on former occasions.

Many landaus of various forms were shown, all accessible with a single step from the ground, as has been usual in England for many years—none are so light as those that have been made in England to be drawn by one horse. Nearly all have the doors arranged to open with the glasses up (a system not adopted in England on account of the rattle). The system of balanced heads now generally adopted in England has not received the attention in France that so great an improvement deserves, as such heads when well made, and properly and carefully used, can be opened and closed instantly—a great convenience when carrying ladies, or when rain comes on suddenly. One unpainted landau was shown, which had no glasses to the doors; it was sold to go to South America. Nearly all the landaus have deep drop doors of angular pattern, and low driving seats.

In the French department were some good examples of private omnibuses—carriages much used in France, and in which French builders have made some reputation. Nearly all are well hung, especially behind, but the front axles being invariably shorter than the hind ones, four tracks are cut by the wheels on bad country roads, causing heavier draft, a drawback that is hardly compensated for by a shorter space between the front and hind wheels.

Victorias were shown by French and Belgian makers, and it is remarkable how caprices of fashion may tend to bring down a standard of style and quality that had been previously attained. The French victorias have been much changed in the proportions and style of former days. The panels of the bodies are now of excessive and unnecessary depth, the outlines are without much refinement and symmetry—although mostly of cabriolet form, they need not therefore be ungraceful—the hind elliptic springs in many cases are placed outside the bodies, and the line of the springs often cuts across the bottom line of the bodies.

Mail phaetons on perch carriages and mail springs indicate a growing taste among French and foreign buyers to drive their horses themselves, as an amusement and exercise of skill and judgment in the management of horses—a type of carriage that should always be well horsed and thoroughly well turned out in all respects, from harness down to the livery, hat, boots, gloves, and necktie of the servant. Those shown were nearly all heavier in construction than have been made in London for some years, nor did they approach the best London types in respect of outline, proportion, symmetry, or style; one has a jointed perch, the intention being to prevent the carriage being twisted on bad roads, and also to preserve the equilibrium of the body when thus tried.

Several two-wheel dog-carts were shown by French makers, greatly improved on former exhibits, well hung, and finished in good taste.

There was a fair number of broughams among the French and Belgian carriages, chiefly to carry two persons inside. There has been a change of fashion as regards outline, style, and form; most of them have curved lines instead of the straight and angular lines that have so long prevailed; and, complimentary as it seems, they are called London fashion — Barker pattern—from the style and pattern of this firm having for nearly thirty years remained unchanged, while all other makers had fallen in with the fashion, by making their brougham outline angular.

But there is this to be said in favour of well-arranged slightly-curved lines, and a combination with angles, that the lines and proportions lend themselves favourably to the type and form of these carriages, and in the hands of skilful designers who can appreciate and produce harmonious combinations of subtle and delicate curves and angles, the effect and pleasure produced will probably be more lasting than a combination of many and fully-pronounced curves.

Public Carriages of Paris.

The two great and well-organised companies that chiefly provide Paris with public carriages—the Paris General Omnibus Company, and the Paris Carriage Company—showed specimens of the carriages produced at their great works.

An omnibus to carry a larger number of passengers than those generally used in London, and to be drawn by three horses abreast, shows good contrivances and workmanship for the purpose intended. All the parts of these carriages are made to standard sizes, and are interchangeable, so that repairs are greatly facilitated, whether necessary by reason of ordinary wear and tear, or caused by collision or other accidents. By this method the carriages can be kept almost constantly at work and earning money, and the stock of spare vehicles need not be by any means so large as would be absolutely necessary were not such a well-organised plan in regular use.

The brougham and victoria shown by the Paris Carriage Company, which owns 5,000 of these vehicles and 12,000 horses, are carriages of sound construction, and become far more interesting after an inspection of the great works where they are made and repaired. This company, as well as the omnibus company, have several features in common, and their organisation reflects much credit on the ingenuity, enterprise, and capacity of the managers, all tending to a definite object, and for which the French have made a reputation in many branches of industry. The various parts of their smaller carriages are also interchangeable, so that the building of new carriages, providing materials, making contracts, keeping up stock, book-keeping, &c., are all greatly facilitated; parts of all kinds can be readily changed and interchanged; axles, axle-boxes, collets, nuts, and axle caps, springs, lamps, seats, dashers, &c., all fitting each and every carriage. The panels of the carriages of both companies are of very thin iron. I was fortunately provided with introductions, and inspected both factories, by the kind permission of the chief managers.

In order to show how perfect the system of standard sizes had become, two cabs were taken out of stock, a gang of workmen was told off, and within five minutes the front and hind carriages of both were completely exchanged, including hind span iron and cross springs, and both were fit to have the horses put to them, a feat that could not be performed in any other city in the world at this time.

By careful observation, and choice of materials, and improved modes of construction, I was told that the single broughams had been greatly reduced in weight, so that they did not now exceed 400 kilogrammes (881 lbs. English).

In the case of the brougham cabs, a little hinged extra seat drew up from a fastening in the seat rail, and was almost out of sight when not required for use.

I ought here to mention that all this company's cabs are made to carry two persons inside, whereas all the London four-wheel cabs are made to carry four persons inside, are drawn by one horse, and travel quite as fast, or perhaps faster, than the small Paris cabs.

By an ingenious arrangement in the victorias an extra seat for two persons is provided. Two iron rods lie inside each bottomside, jointed about the centre of the doorway; turning up, the seat rests against the back panel of the front boot, and can easily be put out of sight when not required by simply turning it back, when the seat-board rests against the heel-board below the hind seat cushion.

Each carriage is provided with a spring-cushion and spring-back. The heraldry is ingeniously placed on the panel by the transfer process, the paper being carefully removed by rubbing after softening by water.

The public omnibuses are gradually having a patent brake applied to the hind wheels, as, after careful experiment, the system has been found suitable for such work. The back part of the stock of each hind wheel is provided with a channelled iron band; round it is a double coil of iron, or steel wire rope, and attached to the wire rope are three or four pieces of wood; these pieces of wood bear on the iron hoop—they are connected with a foot brake on the footboard by a stout iron wire, and the pressure exerted by the driver's foot seems sufficient to arrest the progress of the vehicle.

Before the invention of elliptic springs by Elliot in 1802 (and for which the Society of Arts awarded him their Gold Medal), and the addition of under-springs to perch carriages about twenty years later, all four-wheel carriages were made with combined wood and iron perches, and heavy transoms, axle-beds, &c. The adoption of the two inventions referred to, and the light iron perch carriages introduced in 1845, by my late father and myself, seemed for nearly twenty years to have thrown out of use all such plain perch carriages; as almost every maker adopted the single bar iron perch where it was possible.

The revival of the taste and fashion of four-in-hand driving during the last twenty years has, however, brought about a revival of the old system of combined wood and iron perch carriages—the wood and iron perches were in the late exhibition applied not only to drags but to weighty mail phaetons, a *char-à-banc*, a barouche, a D'Orsay chariot, and a sociable—small carriages with the single iron perch under-works being shown by France, and also by Spain and Holland.

Having criticised the French carriages on points of construction, I now bear willing testimony to the excellence achieved by our neighbours in their literature of the carriage-building industry. The details of construction are produced so carefully as to materially assist those engaged in the craft.

ARTISAN REPORTERS.

It was found possible to send over to Paris four carefully-selected artisan reporters to examine the carriages at the Exhibition. Two went over under the auspices of the Lord Mayor's Committee, and their reports have been printed with other reports in the volume published by that committee; and our thanks are due to the late Lord Mayor, Alderman Sir James Whitehead, for the interest he took in all the details that tended to render their visits useful and successful. Two others were sent over through the instrumentality of the Institute of British Carriage Manufacturers, of which I have the honour to hold the office of president. These will also shortly be printed and published.

All these reports are highly creditable to the writers, and prove that there are many managers, foremen, and artisans among us who take a real and intelligent interest in the occupation they follow—are competent critics of such work as they were invited to examine, and willing to impart to others the information that the opportunity afforded them.

Many other artisans visited the Exhibition, encouraged by the low fares offered by the railway companies, the low charges for admission, and the comfortable hotel accommodation provided by thoughtful persons interested in the welfare and enjoyments of British working men. My own firm sent over artisan reporters to Paris in 1855, 1867, and 1878, and to Dusseldorf in 1880. Such visits, in our experience, tend to remove prejudices, and to open the eyes of workmen to the necessity of attaining and maintaining a high standard of skill if England is to continue to hold her position as a great manufacturing nation.

The extension of railways, steam navigation, the rapid transit of letters, messages, and goods, have tended to produce an ever extending competition among manufacturing nations, and our employers, managers, foremen, artisans, and apprentices will have to acquire a knowledge of their various and varied occupations in as thorough a manner as has become usual among those of the continents of Europe and America. I will now pass on to a brief review of the French system of technical education and training for carriage-building.

TECHNICAL CLASSES IN PARIS AND LONDON.

There are three well-established, vigorous, and flourishing classes, well supported both by employers and workmen.

The first I will draw your attention to is a private one, founded in 1857 by M. Brice Thomas in conjunction with his brother-in-law, M. Albert Dupont, both brought up as carriage artisans, and both fired, as it were, with an inward feeling and consciousness that they could elevate the industry they were engaged in, and place it in a higher position in the world's estimation.

By dint of study, industry, perseverance, and large-heartedness, they proceeded cautiously and carefully, always borne up and through difficulties and discouragements with the feeling that their country would one day recognise and appreciate their efforts. That recognition has come; others have reaped solid advantages from their intelligence, foresight, and straightforwardness, and they toil on, cheerful, contented and happy in their self-constituted task.

After a time, M. B. Thomas established himself elsewhere as journalist—producer of small coloured drawings of carriages to scale, and an investigator of the sciences that underlie the art of the carriage manufacturer, and lecturer to the technical class I shall presently describe.

This class is maintained for the sons of employers chiefly, who come not only from Paris, but from all parts of France, and indeed from all parts of the world; and every city or town that has sent a steady and suitable student to go through the six months' teaching, has received advantages from the teaching and practice there received.

The class is held at 29 Rue Guyot, Ternes. The hours of attendance are 8 a.m. to 5 p.m., with an hour for *déjeûner*.

The rooms are spacious and well-lighted; and the walls are covered with carefully-jointed pine boards, with even surfaces and painted black. Several of the boards have long rulers, say twelve to fourteen feet long, having a parallel action behind the boards to maintain their exact horizontal action when used. Others have accurately-fitted horizontal pieces of wood fixed near the floor, on which large square boards can be placed to draw lines absolutely at right angles to the ground line, and against which other smaller square boards can be placed for drawing other horizontal lines when required.

The younger students commence by drawing simple figures with chalk on the black-board, and as they attain precision of touch, are allowed to draw on immense sheets of paper specially made for this and similar uses, and largely exported from France to carriage builders in various parts of the world.

The students are gradually instructed to draw parts of carriages, simple combinations, till they attain facility in more elaborate and difficult structures.

Each position, combination, and construction has the reason explained, so that many on leaving can design and carry out original work, while a few accomplish the difficult and intricate process of setting out the curious combination of curved lines that comprise the Salisbury boot that sustains the hammercloth of dress and court carriages.

There is accommodation for about eight students at this establishment, and the fee for the six months' course is about £24.

The next technical class has been established by the Syndical Chamber of Carriage Builders of Paris, in a well-planned and well-lighted room, the large window next the street occupying the whole frontage, and the entrance being at the back opposite the window. The black-board occupies the whole end of the room opposite the window, is raised about 3ft. from the ground, and has two large and wide steps running along the whole length, and providing a convenient platform for the lecturer or demonstrator, who can readily make his illustrations on the board with white chalk.

It was here that I had the good fortune and pleasure to hear M. Brice Thomas deliver his 32nd annual inaugural lecture, which I shall presently notice.

The lecturer's private room is well furnished with handsome certificates of the honours bestowed on this class by their fellow countrymen.

The third technical class was founded by the Carriage Workmen's Syndical Chamber in 1872, in accordance with one of the rules of their trade union, which enjoins this action, as well as that efforts shall be made for the proper instruction of workmen's sons, in order to render them competent artisans. It is now held at No. 11, Avenue des Ternes, having been removed from its original *locale*, 35 Avenue Wagram. It meets on Tuesdays for lectures, and on Wednesdays, Thursdays, Fridays, and Saturdays for drawing and technical demonstrations, the hours being from eight to ten o'clock each evening. The fees are two francs per month.

I regret that circumstances prevented my visiting this class, but hope some of my fellow countrymen will arrange to do so now that its situation, days and hours of meeting, are made known. I was told that it has about sixty students.

The following are the general regulations of this Technical Class:—

Art. 1.—The class is intended for the technical teaching of drawing in its special application to the construction of carriages.

Art. 2.—No student may compete for prizes after completing a three years' course in the class.

Art. 3.—All French carriage workmen are eligible as students to whatever branch they belong, and whether members of the Syndical Union or not.

Art. 4.—The fees payable by students (not members of the trade union) are two francs (20 pence) per month; but the fee of the members of the trade union is 1 fr. 50 c. (15 pence) per month.

Art. 5.—Free instruction is given for two years to apprentices who have served one year of their time in any branch of the carriage building industry.

Art. 6.—The classes are held in the evenings from 8 to 10. Tuesdays, lectures; Wednesday, Thursday, Friday, and Saturday, drawing in its relation to carriage construction.

Art. 7.—The expenses of the class are provided for by (1) the fees paid by the students; (2) donations, legacies, and subscriptions offered and accepted by the Syndical Union with the object of aiding the work; (3) the Syndical Chamber pays the balance necessary to meet the expense of maintaining the efficiency of the class.

Art. 8.—The class is under the control of the Syndical Chamber of Paris carriage workmen.

Art. 9.—The council nominates the professors and demonstrators, who shall afterwards be presented at an extraordinary general meeting specially summoned to receive the presentations, and the general meeting confirms or rejects the nominations. The council's duty is to select the candidates in such manner that each branch of the trade shall be fairly represented, so that in the technical teaching, the students may have theoretical and practical instruction from persons employed in the same branch of industry.

Art. 10.—Salaries are attached to the offices of professors, assistant professors, or demonstrators, as well as to the secretary.

Art. 11.—The professors have entire responsibility for the programme of studies, the organisation and discipline of the class, after submission to and approval by the executive council.

Art. 12.—Every three months the secretary is to present to the committee charged with the administration of the class a detailed report of its condition as well as a detailed account of receipts and expenditure during the three months; the committee send these on to the executive council, who present them afterwards for approval at a general meeting of the members.

Art. 13.—None of the professors or students—members of the society—are eligible to act on the executive council while attending the class as professors or students.

Art. 14.—At the end of each session there shall be two competitions in each section.

Art. 15.—The winners of the two highest prizes, on the completion of their course of study may (of right) receive the title of assistant professor, and they may still continue attending the class meeting in that capacity; they being eligible for the office of professor when vacancies occur. Nevertheless, any student who has once received a first prize, and again competes, loses all his rights if he does not succeed in attaining at least a third place in the competition he engages in.

Art. 16.—An additional class or classes may be established by the Syndical Chamber, whereas it can be of advantage; but the new sections thus created must first be assured of special and sufficient funds for their existence and maintenance.

Art. 17.—These rules and regulations may be revised on the condition that a resolution to that effect be sent three months before a general meeting is held.

It appears to be now the general opinion that it is high time we returned the compliment of our neighbours by learning something from them, and therefore I have submitted this information on French Technical Education as applied to carriage-building. Before proceeding to a comparison of the English and the French systems of technical education, I will give a condensed report of Mons. Brice Thomas's lecture, "On the General Principles relating to the Construction of Carriages." It was my privilege to be present when this lecture was delivered at the inauguration of the 32nd session of the Technical Class for Carriage Builders, held under the support, and by the assistance of, the Syndical Chamber of Carriage Builders (whose office for business purposes and conferences is at 3 Rue de Lutece Cité). The meeting was held in the new classroom, provided and specially built for the class, at 22, Rue Langier, Rue de Courcelles, Ternes, on the evening of Tuesday, 8 p.m., October 8th, 1889.

The subject was divided under five heads:—

(1.) The usual dimensions of carriages.

(2.) The proper position of the load on the wheels.

(3.) The manner of suspension, and proper position of the springs and axles.

(4.) The formulas in use.

(5.) The methods of calculation applied to construction, generally, but not in all cases, applicable without modifications.

I. The measurements and proportions in general use.

These dimensions for private carriages are generally based on the sitting accommodation which it is necessary to provide for persons of average size.

He remarked on this subject that any alteration of usual measurements involved alterations and adjustments of the measurements of all the other portions of the carriage.

That the designer who aims at perfect proportions and successful results must always bear this in mind, and if requested by a purchaser to vary measurements, should do so within reasonable limits, and subject to alterations in other proportions, otherwise the result on completion would be unsatisfactory. Carriages may be built of any proportions, according to the desires, necessities, or caprices of purchasers with fairly satisfactory results, if the proportions of the various parts are made suitable, in order to produce a harmonious and pleasing result; the chief measurements to be first fixed as a guide to others would be the width and depth of the seats, of the body, the head room, and the leg room.

II. Draught.—In order to attain the best results as regards facility of traction, the proper position of the load on the wheels must be aimed at.

The strength of the springs should be in proportion to the weight they have to carry, and the work they have to do. They should be placed in such a manner that all the parts of the carriage itself shall bear equally on the springs when carrying the full load that the carriage is made to sustain. It is therefore necessary to calculate what proportion of the load is to be carried by the hind wheels and springs, and what proportion by the front ones, in order to adjust their size and strength to attain the best results. Illustrations were then given on the black-board in relation to draught.

Much would depend on the accurate fit and the exact and hardened surfaces of the axle-boxes and arms, which, if of the very best make, would cause little friction to impede draft, but it would be otherwise if imperfectly fitted or soft axle-arms and boxes were used.

The different effects on draught, and the force necessary to overcome and pass obstacles on the road, were shown by a diagram of a weight suspended by a cord, and attached, first, to a small and then to a large circle, the spoke in a horizontal position representing the radius, and acting as a lever, of small power when short and of greater power when long. Thus a weight attached to the circumference of an axle-box might require 100 lbs. to turn it, while one of 5 lbs. attached to the circumference of a wheel at a point near the end of a spoke in a horizontal position would be sufficient to move the wheel.

(*a.*) The draught would, in addition, be affected by the number of persons, &c., carried on the carriage.

(*b.*) The condition of the road surface, whether in good or bad order.

(*c.*) The inclinations of the road surface, whether level or hilly.

III. The manner of suspension, and the proper position of the springs and axles.

It is always necessary to consider the axles as bearings, and the springs resting on the axles as the arms of levers.

Here it will be necessary to know the exact width of the hind part of the body in order to regulate

(*d.*) The length of the axles.

(*e.*) The width of the axle-flaps that are to carry the springs.

(*f.*) The space that shall be allowed between the outside of the body and the inside of the hind wheel.

The French practice is to regulate the width of the front boot in proportion to the length of the front axle (generally made from 6 to 8 inches shorter than the hind one, to describe a smaller circle in turning, and consequently it can be placed about half that distance—3 to 4 inches—nearer the body than if the front axle were made the same length as the hind one); but as in bad roads the front wheels cut a narrower track than the hind ones, and four tracks are cut instead of two, the resistance is increased, and the draft is impeded more than with British carriages, where the hind wheels follow in the same track as has been already rolled by the front ones. The space between the front wheels and the driving boot of English carriages is therefore usually greater than in French ones, the width of the boot in each case being very similar.

The position of the hind wheels in carriages having doors in the sides, is guided by the position of the doors, which are now generally made to open back, as they then act as guards to protect the clothing of persons entering from contact with the muddy surfaces of the wheels.

In every case the hind wheels must be so placed as to allow the doors to open freely, and at the same time to allow sufficient space to prevent the wheel-tyre cutting the panels of the door and injuring the surface, and to be clear of the arms and blocks of the lever brakes when such are applied. They have also to be placed so as to allow sufficient space for the leather-covered wings that protect occupants from splashing of mud. They have also to be so placed, especially in wagonnettes, brakes, omnibuses, and *char-à-bancs*, as to sustain the load in an efficient manner, and maintain, as far as possible, the equilibrium of the carriage when loaded.

Other illustrations were given of the action of the springs as levers, and the necessity of adjusting the proportions accurately, as it is not in all cases possible to alter the position of the axles to give the best possible proportions to the springs, though a satisfactory compromise can generally be effected.

He then demonstrated the difficulties that have not been overcome in the case of the use of C springs without the addition of a perch or connection of some sort, and which have been so extensively used in England of late years, that the action of the curved and flat portions of the springs are in actual antagonism, and that in consequence the elasticity expected and resulting from springs made in accordance with scientific facts and truths is not attained. A very small portion only of the spring has any movement, and the form, considered alone, is deceptive, and has, therefore, wisely, not been adopted by French builders, or by any English firm of the first rank.

IV. Formulas in use. Here he called attention to a matter of importance for the consideration of the students. A manufacturer may be called upon to produce a carriage of which the measurements may vary considerably from those generally in use, and from the proportions with which he may be well acquainted through constant use and practice. In such a case, it would be well for him to have some reliable basis of calculation that has been tested and approved by the practice of makers of experience.

He showed by the proportions of axle-arms usually adopted by makers of private and public carriages, and which experiments, use, and experience proved to be suitable, that they corresponded with the results he had worked out and tabulated, by taking the actual weight carried by each axle-arm, calculated from the weight of the vehicle, and adding to it the weight of the persons to be carried. In some cases allowance has to be made to meet conditions of probable use, such as carriages habitually driven very fast, and two-wheel carriages used with wheels of extra height, acting as levers of greater force than smaller ones, the axles in such cases having to be made of greater diameter to resist the additional strain with safety.

V. The methods generally adopted. It may be said of the methods of investigation and their results, that they are useful and applicable within certain limits, to ascertain the unknown from the known. As an example, let us take a large pair-horse carriage; by dividing the diameter of the naves by the diameter of the axle-arms, we find the former just 4½ times greater than the latter.

If a four-horse drag were built of similar proportions in regard to the axle-arms and the wheel naves, and if, according to the tabulation already referred to for proportioning the size of the axle-arms to the weight to be be carried, the diameter of the axle-arms was so made, the wheel stocks would evidently be much too large. He cautioned his audience, therefore, that the table of proportions would not hold good in every case, without exceptions.

By carefully joining scientific truths, and with the experience gained by watching processes and the effects in actual use, a very fair approach to actual results was now within the reach of careful students who would think over their work with a view to improvement.

Details Concerning the Technical Classes for Students of Carriage Construction in Paris and London :—

PARIS.

For Sons of Employers and Others Training for Employers.

Location.—29, Rue Guyot, Ternes.

Duration of Session.—Continuous; the usual term is six months.

Days and Hours of Classes and Lectures.—Daily, 8 a.m. to 5 p.m., allowing one hour for *déjeûner*.

Number of Students on Register.—Varies, eight.

Average Attendance.—Five.

Number of Teachers.—One; and one assistant.

Fees Payable by Students.—£24 for the six-months term (or course).

General Expenses, and How Provided For.—Private adventure.

Arrangements and Methods of Teaching.—A large drawing board, say 13 ft. by 7 ft., for each student; copies of full-sized working drawings of parts, and of entire carriages; verbal instruction as required by each student; practice in making full-sized drawings of carriages on paper; arranging the position of the parts so as to be correct as machines for the work intended, and pleasing to the eye as regards proportions and harmony of parts and lines.

Class of the Syndical Chamber of Employers.

Location.—22, Rue Langier, Rue de Courcelles.

Duration of Session.—Six months, October to end of March.

Days and Hours of Classes and Lectures.—Every weekday except Monday, 8 p.m. to 10 p.m.

Number of Students on Register.—About sixty.

Average Attendance.—Forty-five.

Number of Teachers.—Four.

Fees Payable by Students.—1s. 8d. per month; returned in prizes.

General Expenses, and How Provided For.—Contributions from employers in uniform proportion.

Arrangements and Methods of Teaching.—Occasional lectures by specialists in various branch and accessory trades; copying scale drawings; designing parts of carriages and whole carriages; geometry in its application to carriage building; the proper setting out of the work; methods of construction, framing, and fixing together.

Class of the Syndical Chamber of Workmen.

Location.—11, Avenue des Ternes.

Duration of Session.—Six months, October to end of March.

Days and Hours of Classes and Lectures.—Every weekday except Monday, 8 p.m. to 10 p.m.

Number of Students on Register.—Eighty-eight.

Average Attendance.—Sixty.

Number of Teachers.—Six.

Fees Payable by Students.—1s. 8d. per month to non-members; 1s. 3d. per month to members. Free instruction for two years to apprentices who have served one year of their time.

General Expenses, and How Provided For.—The secretary reports every three months to the Chamber the condition of the class teaching, and sends in a detailed account of receipts and expenditure.

The municipality of Paris subsidises the workmen's class to the extent of 5,000 francs per annum, and the Minister of Commerce subsidises the employers' classes to the extent of 2,000 francs per annum.

LONDON.

POLYTECHNIC YOUNG MEN'S CHRISTIAN ASSOCIATION.

Location.—309, Regent-street.

Duration of Session.—First Monday in October to end of April.

Days and Hours of Classes and Lectures.— Mondays, 8 p.m. to 9.30 p.m.

Number of Students on Register.—Sixty-one.

Average Attendance.—Forty-five.

Number of Teachers.—Two certified, two assistant.

Fees Payable by Students.—4s. for the session.

General Expenses, and How Provided For.—The patriotic liberality of a great London merchant.

Arrangements and Methods of Teaching.—The work of the session ss graduated, and special attention is given, as far as possible, to slow students. Geometry is taught in its relation to carriage building; perspective, as regards carriage delineation; general outlines of carriages and parts of carriages; scale drawing (space does not allow full-sized working drawings to be made, they are therefore made half-size); lectures at each meeting; general considerations that should govern the designing of different parts; choice of materials; what to avoid. Prize distribution, with a little ceremony, by some invited chairman.

BOARD OF GOVERNORS OF THE UNITED WESTMINSTER SCHOOLS.

Location.—Palace-street, Westminister.

Duration of Session.—First Tuesday in October to end of April.

Days and Hours of Classes and Lectures.— Tuesdays, 7.30 p.m. to 9 p.m.

Number of Students on Register.—Twenty-two.

Average Attendance.—Sixteen.

Number of Teachers.—One certified.

Fees Payable by Students.—4s. for the session.

General Expenses, and How Provided For.—Cost £27 to £37 per year. The governors of the school provide the room, firing, and lighting free; a grant of £10 from the Coachmakers' Company; students' fees; £10 subsidy from employers. In one case, the employers pay all the class fees for their apprentices, regular attendance at the classes being a condition of employment, and if satisfactory, each receives a small present at Christmas time. A little ceremonial takes place at opening the session.

Arrangements and Methods of Teaching.—The teaching in this class is very similar to that described above (Polytechnic).

The Institute of British Carriage Manufacturers, about three years ago, with the aid of industrial and scientific experts, drew up a complete scheme of education suitable for all grades of persons engaged in the carriage building industry.

By a glance at the various details of the classes in Paris and in London, their aims, organisation, and manner of carrying out their work, experts will notice a certain similarity on some points and considerable variation on others. For instance, in the foundation, maintenance, and management of the two for workmen and apprentices, one is under the immediate control of the Syndical Chamber of employers, the other under that of the Syndical Chamber of workmen.

The higher establishment for the training of employers, managers, and foremen is a strictly private enterprise, being carried on by the teacher, with his sons as assistant teachers; its equipment is complete, for its purpose, in all respects; the expenditure has been judicious and the fees for tuition are moderate; its influence during more than 30 years has been great, and has extended on the East to India and the Colonies and on the West to the remote Pacific Coast of America. The number of students in proportion to population is far larger in Paris than in London. I have not been able to lay before you statistics of the provincial classes in France or England, but it would be advantageous and desirable that they should be obtained.

It has to be admitted that we in England have not worked on any defined and organised method as regards such classes; we have taken advantage hap-hazard of such rooms as were available and suitable. And here I may mention how opportune was the accommodation offered for a class at the Regent-street Polytechnic, when Mr. Quintin Hogg was organising the technical classes there that have been rapidly and successfully paving the way for a more systematic and elaborate organisation of teaching. He has, as a Christian philanthrophist, offered a place of meeting for instruction, recreation, and pleasurable enjoyment to thousands of young Englishmen who have had to resort to London for improvement and finish, and who have had their skill and knowledge advanced, free from the many snares and temptations that beset young men first entering into life, and arriving without friends to cheer and advise them and keep them in the straight course.

The Board of Governors of the United Westminster Schools, anxious to aid technical education, offered a room, lighting, and firing, which has provided a home for another class that is doing good service.

In one respect our English organisation is more complete than that of Paris, for, through the instrumentality of the Society of Arts, annual examinations have been held for about 17 years in this and many other subjects; and whatever may be said against examinations, as regards methods and schools, the system seems to be almost the only possible one for ascertaining what and how much the students know. Having held the office of examiner for seven years, I feel that in order to vary the questions, and prevent the teaching and learning being one of "cram," an examiner, after a time, has a great tendency to set far-reaching questions, and it might be well to associate one or more assessors with an examiner in setting the questions. These assessors might be chosen to act as examiners, after the examiners had held the office for say five to seven years.

In Paris the prize distribution is accompanied with some ceremonial, the prizes are handed over by some person of distinction, who dilates on the subjects taught, and gives the students words of commendation and encouragement. The friends and relatives of the teachers and students are invited, and music and festivity accompany the prior formal proceedings of the day.

PARIS TRADES UNION.

I will now pass on from the educational system, and add some notes on the constitution of the trades union of the carriage workmen of Paris.

My information is drawn from the rules of the "Syndical Chamber of Carriage Workmen of Paris."

These rules have been thoughtfully and carefully drawn up, and set forth clearly that one of the objects of the Union is to raise the rate of wages by all means allowed by the law.

Another rule laid down is that a technical school shall be established and maintained for the advantage of the Paris workmen. And another, that the sons and young relations of the members shall be carefully taught their trade in the workshop and the technical class, in order to render them skilful workmen and good citizens.

I here append some translated extracts from the rules:—

Art. 2.—The object of the society is to provide money for the assistance of those members who may be without employment, owing to disputes between employer and workmen on the question of wages. To maintain, and also to raise the rate of wages by all legal means that the society may consider necessary and equitable. To open a registry-office for carriage workmen of all branches without charge. To create and maintain a technical class for the proper instruction of the members.

Art. 5.—The contributions of members is fixed at 5d. per month.

Art. 6.—Classifies the various trades employed in carriage manufactories. The members of the society are divided into six groups—body-makers, carriage-makers, smiths, vicemen, painters, and trimmers.

Art. 7.—The workmen engaged in the accessory trades, besides these six branches, are eligible as members, and are grouped with the branches to which their occupation is most nearly allied.

Art. 8.—Each group or branch is to elect a special committee of as many members as may be deemed necessary, and whose duties are to elect members of the executive council; the classification or revision of the prices to be paid in each branch of labour; the preparation of reports for discussion by the Syndical Council.

Art. 13.—The executive forms (or elects) its bureau (or administrative committee) at the commencement of each of its meetings, and its composition is a treasurer, a general secretary, and an assistant secretary (if considered necessary).

Art. 14.—The Chamber's duty is to watch over the moral, intellectual, and material interests of each branch of the society; to direct attention to every measure and reform that may tend to the progress, prosperity, and development of the work and welfare of the artisan, whilst respecting the principles of liberty and equality, which are the foundation of the economic conditions of those engaged in handicrafts.

Art. 15.—The Chamber is to take part, as far as possible, in the discussions and disputes that arise from time to time between employers and workmen. Whenever questions of general interest arise it is to communicate with the Syndical Chamber of the employers by means of a deputation, and use every effort to to arrive at a fair settlement by consultation and conciliation. It is, however, understood that its decisions and resolutions can only have a moral effect.

Art. 16.—The Chamber will advise fathers of families as to the placing out of their sons, and see that the young people are encouraged and protected by the members, so as to render them not only skilled workmen, but worthy and honest citizens.

Art. 17.—An employments register is to be kept up. First column to receive the names of workmen seeking employment; second, the names of employers requiring men; third, information communicated by members.

Art. 19.—The chamber is to found and maintain a professional technical class out of the subscriptions of the members. Nevertheless those who attend the class are expected to contribute a small fee to help to defray the necessary expenses.

Art. 27.—The executive council is to consist of 21 members at the utmost, and to contain an equal number of representatives of each group or branch of the industry.

Art. 28.—The executive council requires a quorum of two-thirds of the members to render any business it may transact valid.

Art. 29.—Any member of the executive council absent from three consecutive meetings without sufficient reason vacates his seat.

Art. 30.—The services of the members of the executive council are honorary, but a payment may be allowed to such as are specially required to give extra time and attention to carry out the orders of the council, if they are thereby required to absent themselves from their ordinary employments in order to serve the society. This allowance, however, must be sanctioned at a general meeting of members.

Art. 34.—All business transacted in the name and in the interest of the society must be first authorised by the signatures of three members of the general committee.

Art. 38.—Any member whose subscription shall be twelve months in arrear ceases thereby to be a member.

Art. 42.—Any member whose immorality is notorious may be expelled—as also any who does not conduct his intercourse with his fellow-members in that spirit of fraternity which should exist in all properly organised workmen's societies established to promote the interests of all the members.

Art. 43.—The expulsion of a member can only be effected at a general meeting, after investigation and recommendation by the executive council.

Art. 45.—The date of the foundation of the society is fixed at June 23, 1872.

Then follow eight ruled pages for the lists of contributions extending over eight years.

PUBLIC CARRIAGES OF PARIS.

Paris General Carriage Company.—The offices are at No. 1, Place du Theatre Français, close to the Rue de Rivoli and the Louvre, and the works at a considerable distance—Rue Aubervilliers; they cover many acres of ground, and consist of many separate, solid, and well-lighted buildings, well adapted for their purposes. Single broughams and victorias are the carriages made and used, both are small and of standard sizes, the various parts being interchangeable, and workmen have to work accordingly; the parts are tested as they proceed, to ascertain that such regulations are adhered to.

The panels are all of iron, rolled extremely thin, and well fixed and adjusted.

The front parts of the carriages, where exposed to the action of water, by rain or in washing, seem to rot away even more than in England (notwithstanding the drier climate of Paris), and require costly repairs. In summer, victoria bodies are placed on the wheels, springs, and axles used under many hundreds of broughams in the winter.

Almost all the workmen are paid for piecework (*i.e.*, not by the time consumed but for the work completed); even repairs are paid for on this system.

The work is offered to a gang or company of workmen at a price agreed on. They estimate each others working and productive powers as to daily wages, and on completion of the work divide the profit earned beyond the wages received; but the workmen, among themselves, give in practice no encouragement to an equal rate of earnings irrespective of capacity for earning.

Paris General Omnibus Company.—The works are at 34 Rue Championnet, Buttes Montmartre, and cover nine hectares of land, and consist of many large, well-planned, spacious and well-lighted buildings. The whole establishment is well organised, with suitable machinery for various purposes. There is ample and excellent accommodation for converting and seasoning timber, of which there was a large stock of excellent quality admirably arranged for seasoning.

Nearly all the labour is paid for by the piece. The tyres are rolled without a weld and the sizes vary slightly to suit new, slightly worn, or much worn wheels. The springs are tested in suitable machines. The axle-boxes are all of bronze, and when worn, the metal is again cast into new ones; the axle arms are lubricated with a cheap mineral oil. Here, again, the panels are of very thin iron.

A great deal of the varnish used is English. I may here add that English varnish goes all over the world, not only by reason of its merits but also through the enterprise of the manufacturers, who send their travellers all over the world to assist the makers of carriages in putting a brilliant finished surface that attracts buyers, and at the same time keeps out the moisture that would rapidly injure articles so constantly subject to mud, rain, and water.

Here all the timbers exposed to much moisture is of oak—oak being sometimes used for poles.

The harness is also made on the works; much of the leather is very carefully cemented as well as sewn, the sewing being done by a French machine where the thread fills the holes, and is also drawn tight in the process of making the stitches.

The interior seats are divided by rails and elbows, so each passenger gets the measured space he pays for, and stout ones cannot squeeze the thin ones so unmercifully, as sometimes happens in free and happy England.

HORSE FORAGE OF THE PARIS GENERAL CARRIAGE COMPANY.

I will now submit a few observations which I made upon the forage of the Paris General Carriage Company, from which you will see the extremely careful and scientific manner in which our neighbours treat the subject. The directors being desirous of ascertaining the reasons of the sickness and mortality among the company's horses, directed special inquiries and investigations, with a view to ascertain, if possible, the causes, and then took precautions and remedies to reduce both.

It was found that many horses suffered from indigestion and imperfect nourishment; on dissecting them, large balls and masses of hard substances were found in the intestines, which, on being analysed, were ascertained to be composed of calcareous and silicious particles, cemented together by phosphate of ammonia and magnesia, and which must have caused the animals intense discomfort and pain, ending in death.

With a view to preventing this, the whole of the food is now carefully cleaned and all impurities are removed.

In order to ascertain the nutritive value of the various foods, a series of experiments were conducted in a specially-prepared stable attached to the company's laboratory.

The food was first analysed to ascertain its exact constituents, and given in carefully-weighed quantities. The excreta, liquid and solid, were collected separately, weighed and analysed. It was then ascertained what proportion passed through the horses undigested, and was food wasted, and what had been profitably assimilated in repairing tissue, and producing heat or force.

In the course of the prolonged investigations it was ascertained what amount and kind of food produced the best results in keeping the animals in health "while resting" and "while at work," for which latter purpose a testing apparatus had been arranged in a yard outside the stable.

The food now consists of oats, beans, maize, maize cake, oat straw, wheat straw, with small quantities of bran and haricot beans. The impurities taken out consist of 5 per cent. from oats, 6 to 7 per cent. from beans, and 1 per cent. from maize. On resting days each horse receives (in the stable) four feeds.

The object of the forage works is to clean the food and prepare it for the 12,000 horses, in such manner, kind, and proportions as shall keep them in the best of health, reduce the mortality, and at the same time promote economy by preventing waste in every possible way. The maize cake is the residue of maize after being boiled for the production of liquor afterwards distilled. From the forage as it arrives are extracted much earth, seed husks, strange seeds, and dirt of various kinds, besides many small pieces of iron that arrives with the maize, or is extracted by magnets.

There is a laboratory, with an able scientific chemist, a stable for experiments, and all equipped in the most complete and liberal manner. The forage on arrival is analysed to ascertain its feeding value, and to ascertain if the price is suitable and fair.

In the experimental stable many investigations have been made, as to how much food goes to nourish and sustain the health and strength of horses, and how much is undigested, unused, and wasted.

Calculations and experiments have gone hand-in-hand; a system was laid down, adhered to, and the health and strength of the horses has been improved and the mortality much reduced.

Each cab horse is considered to travel 60 kilometres each working day, and to work on alternate days. On asking the custom in England, and being told that horses worked every day with shorter journeys, the director said he considered the English system better than the French.

You will notice (from the Table on p. 475) that no hay is provided for these horses, and that chopped straw replaces it; the horses even consume water by measure. The horses suffer more from heat than any other cause and on very hot days there is a mortality of from four to eight horses, sometimes reaching ten in a day, as on one Sunday towards the end of last September.

The details have been compared with such English practice as I could obtain information about, and I give you the facts, almost without comment, for I do not claim to possess such knowledge on the subject that I should feel justified in placing it before you. I will only add that from the point of view of several practical Englishmen who have been so good as to furnish me with

DAILY RATES OF FOOD, &c., PROVIDED FOR HORSES.

	PARIS.						LONDON.								SCOTLAND.	
	General Carriage Company.						General Omnibus Company. All food eaten in the stable.		Messrs. Tilling, job-masters and cab-owners.		Carriers.				Glasgow Tramway Company. §	
	Working-day.				Resting-day. All food eaten in the stable.						Resting-day.*		Working-day.†			
	Food eaten in the stable.		Food carried in the sack.													
	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.	lbs.	ozs.
Hay	—	—	—	—	—	—	5	0	8	0	12	0	10	0	11	0
Oat straw	2	1	—	—	8	2	—	—	2	0	2	0	2	0	—	—
Wheat straw	—	—	—	—	—	—	4	0	—	—	—	—	—	—	—	—
Oats	—	—	7	4	—	—	—	—	10	0	7	0	crushed 13	0	4	0
Maize	3	4	2	3	13	7	15	0	10	0	—	—	—	—	10	8
Maize cake	0	7	—	—	1	12	—	—	—	—	—	—	—	—	—	—
Beans (crushed)	—	—	—	—	1	2	—	—	—	—	—	—	‡ 4	0	2	0
Beans (horse)	0	6	—	—	1	9	2	0	—	—	—	—	—	—	—	—
Peas	—	—	—	—	—	—	1	0	—	—	—	—	—	—	—	—
Bran	—	—	—	—	0	7	—	—	—	—	4	0	—	—	—	—
Green food	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Carrots	—	—	—	—	—	—	—	—	—	—	4	0	—	—	—	—
Total	6	2	10	8	26	7	27	0	30	0	29	0	29	0	27	8
Average daily weight of food	21	8½					—	—	—	—	—				—	—
Bedding	½ cwt. per week.						—		—		per week. Moss peat litter... 28 lbs. In stalls .... 36 „ In boxes .... 54 „				—	

* Horses rest on Sundays, not on other days, unless unable to work.

† When horses are out all day, about one-third of the food is consumed from nose-bags; but nose-bags are not generally used.

‡ Varies according to season; hay and oats are sometimes substituted.

§ About two days in each week a part is boiled with turnips, linseed, barley, or bran; peasemeal is also mixed with the drinking water.

figures and facts, that in England the fact of horses having varying tastes and appetites is considered, and the food is varied according to the seasons; whereas in Paris, the system, however excellent, scientific, and suitable there, takes no account of the tastes and appetites of the animals, and seems somewhat monotonous.

PUBLIC CARRIAGES OF LONDON.

By the courtesy of Mr. Crane, I have, since my return from Paris, had an opportunity of visiting the carriage building factory of the London General Omnibus Company, and although the establishment is not organised on the somewhat grand scale of the Paris Omnibus Company, the utmost pains have to be taken to produce sound vehicles suitable for the requirements of the London traffic; for I ought to mention that although vehicles, horses, harness, and men are provided by the Paris and London companies, the organisation of the two and the conditions under which they do business are essentially different, for whereas the Parisian system revels in organisation from beginning to end, and no doubt by a rigid system of registration, order, and inspection carries on its work with great advantage to the passengers who ride in and on the vehicles, the London Company seems to set at nought "red tape," and by economical methods, arrangements, and control gets through a large amount of difficult work, affords a large amount of convenience to its supporters by rapid transit, safety, and punctuality, and if it does not provide all the comforts and luxury of a private carriage at a fare of one penny, few persons can say that riding in London omnibuses is an expensive luxury.

Considerable progress has been made in the adoption of standard sizes, which is much more advantageous where large numbers of similar vehicles are made and repaired, than in establishments, large or small, where the vehicles vary in proportion, patterns, or types; and until a manufacture has reached a certain standard of perfection would be a source of loss instead of economy, for while the work is yearly progressing and improving, fixing a standard almost necessarily implies little if any alterations of patterns or proportions, and has to be entered on with the utmost caution. However, a fair approach towards perfection having been attained, the sooner the working parts of similar carriages are made to the best standards, the sooner facility of manufacture and economy commence; thus the axles, wheels, springs, wheel-plates, and fore-carriages are made to standards and are interchangable, as are many of the small iron plates and stays. In case of a breakage or collision disabling a vehicle, the parts can generally be restored in a few hours, enabling the carriage to continue earning money.

In order to meet the public taste, the Company is now building all its new vehicles with a series of chair-seats on the roof, approached by a light, curved staircase, rising from a large platform at the hind part of the body. Although apparently a simple change in the manner of carrying the load, it has involved a totally different method of making the roofs; and although the cost is increased, the public and the Company are alike benefited—for the outside seats are more comfortable, and at the same time are more used, thereby helping up the Company's dividend, as a sort of set-off to the marvellously low fares now charged; and the existing vehicles, as they need repairs, are also being rapidly transformed and have the new pattern roof seats, staircases, and platforms added.

To save undue weight, mild steel is extensively used, and incessant watchfulness seems to be exercised in reducing weight wherever it is possible, and in strengthening weak or rapidly wearing parts by the most efficient methods to combine safety and durability.

The panels here are made of mahogany, those in Paris being all of iron. The wood is not only choice in quality, but well seasoned. There is evidently not only great care bestowed on the designs and proportions, but also on the putting together, with a view to obtaining satisfactory results.

A change is taking place in the lettering of the outside panels and conspicuous portions that many strangers in London will appreciate. The names of the places where the journey begins and ends are being painted in conspicuous letters, so that even "he who runs may read," and the principal streets and buildings *en route* are shown in smaller letters. There are, however, places where the vendors of pills, cocoa, and mustard have overcome the directors, and have tempted them to allow the suspension of large boards or heavy plates of iron (above the windows) recommending their wares, in large letters, that have nothing to do with the route the vehicle traverses. It is possible that the additional number of passengers that would be carried, were these positions turned to a better use, would compensate for the money now earned by the rental of advertisers.

The excellent arrangements made for the preparation of the paints surpass in order, cleanliness, and neatness, any I have seen in England, on the continent of Europe, or in America, and reflect great credit on whoever has the control of this department. It is no wonder the vehicles have such brilliant colours, lines, and lettering as surpass those of other capital cities when the means adopted lead to a satisfactory result.

I would only venture to add one recommendation, that the *employés* should be provided with the illustrations published many years ago by the Science and Art Department, showing the laws of harmony and contrast of colours as laid down by the great Chevreul, so that the brilliant colours may agree with one another, whether in harmony or contrast.

There is no reason why the public vehicles of London should not help to refine the tastes of the people by constantly keeping before their eyes good combinations of colour, and in our dull climate the bright colour of the public vehicles helps to counteract the dull colours of the houses, the pavements, and the roadways.

These omnibuses are compact, handy to drive and turn, and in proportion to their weight they probably carry a larger number of passengers than any foreign vehicles of a similar kind.

I may here add a word upon those other public vehicles, the London cabs. Perhaps it is a sign of the conservatism of the English character that the four-wheel cab is tolerated. It is impossible to deny that it has improved, but it has been in a manner and at a rate peculiar to itself. Taken as a whole, they are coarse and crude vehicles, and entirely unworthy of the British metropolis. The type known as the "Hansom," from the name of the originator, is certainly a far more creditable conveyance. Those known as the "Improved Hansoms" have received much attention, and considerable ingenuity has been exercised to render them commodious and sightly. Many of these now run on wheels with india-rubber tyres, and have C-springs applied to them. But, unfortunately, these springs are so misapplied, that the ease of travelling for many years justly attributed to C-springs is not attained in these public vehicles where the suspension is faulty.

LONDON.—STATISTICS AND INFORMATION RELATING TO ITS PUBLIC CARRIAGES, DRIVERS AND CONDUCTORS, MADE UP TO DECEMBER 31ST, 1889.

Kindly furnished by J. Monro, Esq., Commissioner of the Police of the Metropolis.

Carriages and Men.	Numbers.	Total.	Inland Revenue Licence.	Police Licence.
CARRIAGES.			For 12 months.	For 12 months.
Tramcars drawn by one or more horses	3,062	14,437	All at 15/-	All at 40/-
Omnibuses drawn by two or more horses				
Omnibuses drawn by one horse				
Four-wheel close cabs drawn by one horse...	3,966			
Two-wheel Hansom cabs	7,409			
MEN.				
Stage drivers	5,878	28,715	—	All at 5/-
Hackney drivers	15,513			
Conductors	7,324			

In Paris the number of tramcars is 592; of omnibuses, 626; of street cabs, 5,480; nearly a total of 6,698 public carriages.

A glance at this Table indicates the numbers licensed by the police in London, together with the number of drivers and conductors, and the amounts paid for taxes, licenses, and fees, but gives no clue to the organisation.

Both London and Paris possess vast numbers of public carriages to carry on the personal traffic, but the conditions under which they maintain it are almost as diverse as it is possible to conceive two efficient systems.

That of Paris works under a monopoly (or series of monopolies) granted for a term of years to syndicates of capitalists, and strictly controlled by the municipality; while that of London is the offspring of keen, and even fierce, daily and hourly rivalry. Paris has vast establishments for systematic and orderly management; while London, with a few exceptions, is supplied by a large number of small capitalists, whose establishments are mostly in back streets, and difficult to find by the uninitiated.

CLASSIFICATION OF EXPORTS AND IMPORTS.

I will now glance at a matter that is always of interest to the persons actually engaged in any industry, as regards the condition and fluctuations of imports and exports, for by periodical and reliable information those engaged in manufacturing and financing form some idea as to whether a trade is a rising or falling one, profitable or unprofitable; but it happens that the Government returns in the case of vehicles are given without classification or separation.

There are three important industries engaged in the production of vehicles that have scarcely any connection or inter-connection. I refer to the makers of railway and tramway carriages, private carriages, and public carriages.

A great change has been taking place all over the civilised world wherever rail and tramways have been introduced, in the form and construction of carriages, and specialty in the conditions of production.

England for many years was greatly resorted to by foreigners for carriages celebrated for soundness and durability, but owing to the blighting influence exercised by the existing special and exceptional taxation, supervision, and inspection by officers of the Inland Revenue (for whom special Government books have to be kept and made up), the industry has been relatively falling back, compared with all other British industries that have been relieved from special taxes on their products.

Those engaged in their production are most anxious to know the conditions of imports and exports, and to ascertain the movements of trade.

The following rough and simple classification has been drawn up, and could be easily worked by ordinary Custom-house officials, exporters, and importers, and it is hoped that the Government may be prevailed on to consent to a classification that would be a great advantage to us, and cause but little extra trouble to obtain.

DRAFT CLASSIFICATION FOR CUSTOMS RETURNS OF EXPORTS AND IMPORTS OF PUBLIC AND PRIVATE CARRIAGES TO BE USED ON COMMON ROADS, AND TO BE DRAWN BY ANIMALS (HORSES, MULES, PONIES, OR DONKEYS), EXCLUDING CARTS OR WAGGONS THAT CONVEY GOODS.

	Exports.		Imports.	
	Number.	Value.	Number.	Value.
Carriages on four wheels to be drawn by two or more horses or mules				
Carriages on four wheels to be drawn by one horse or mule...				
Carriages on two wheels				
Small carriages of all kinds on two or four wheels, to be drawn by one pony or donkey				

TRAFFIC OF THE STREETS.

With the vast concourse of visitors who flocked to the Exhibition, not only from the French provinces, but also from many countries near and far, the traffic of the vast number of vehicles in the streets of Paris attracted my attention. It was somewhat natural that the owners of the public vehicles should wish to improve the occasion, as did the hotel-keepers and owners of apartments, by raising their prices; however, the tariffs of fares, once settled with the authorities, was not allowed to be altered, and although the visitors and inhabitants reaped the benefit of travelling at moderate fares, it involved long hours and a good deal of hard work on the horses that drew them, and the men who drove them

In France, and most other countries, horses are driven on the off (or right) side of the road, while in England they travel on the near (or left) side, and it is probable that the more accurate driving of English coachmen is partly attributable to this fact, as by deftly urning the left hand and wrist it is comparatively easy to keep one, two, or four horses on the side next the left hand, but it is by no means so easy to keep them on the off (or right) side of the road, the whip somewhat encumbering the action of the right hand; thus collisions and accidents are more frequent among Paris drivers than with those of London.

There was an opportunity of frequently watching the effects of the traffic being concentrated towards one point, occasionally crossed by other traffic. In very broad streets, avenues, boulevards, or open spaces, it was often extremely dangerous to foot passengers attempting to cross the the line of traffic, sometimes in continuous rows eight and ten deep.

At some parts refuges with raised pavements are placed, but not in sufficient numbers, and at certain street corners policemen were placed to control the traffic and enable foot passengers to cross it; they stood on the pavement, and their presence and powers seemed to have the smallest possible effect. Whether they were raw and new to their work, or their directions and authority were uncertain or limited, their presence seemed to be of little advantage to foot passengers.

The London arrangements are far ahead of Paris in this respect. Our picked London "traffic constables" seem to stand unmoved in the thick of the traffic. By simply holding up an arm they command implicit obedience, and compel respect. The driver knows he is under a power that can, will, and does enforce order, and children, women, young or old, timid or infirm, regard the constable as a friend and protector, able to control the most reckless of drivers be he ever so impatient to give a loose rein to an eager horse.

Streets may be even too wide for safe and rapid traffic combined with safety to foot passengers, who must sometimes of necessity cross eight or ten lines of traffic. In London some of our streets are overcrowded with traffic, while others are deserted. But how does this happen? What traffic is necessary and what is unnecessary? Costly from the number of men, horses, and vehicles employed, and costly from wearing out the road at the expense of heavily-rated householders.

Certain traffic is necessary, useful, and unavoidable, such as to palaces, Government offices, railway stations, law courts, banks, exchanges, bankers' and railway clearing-houses, wool, tea, timber, and general wholesale and retail trade; but there is other traffic that is unnecessary and costly. I refer to the conveyance of food to central markets in London.

Such produce is brought by roads and railways to a few central markets, and may be said to pass the consumers' doors in the suburbs, and then is brought back again at a singular waste of time and money.

In country towns the produce is brought by the farmers and their wives to the market or market-place and sold direct to the consumer for ready money. In London, on the contrary, from old custom, most of the food is taken past the consumers' doors, making a wholly unnecessary journey, just for want of markets in suitable situations to enable the producer and consumer to come together and exchange produce for money, as is done by our more sensible fellow-countrymen in provincial towns.

To the remarks I have made it would be well to add one or two more, as it is a subject affecting the comfort and convenience of dwellers in and visitors to crowded and populous cities, as well as their limbs, and more or less their lives. It is, I believe, a subject deserving far more thought, care, and attention than has hitherto been bestowed on it. In these days of keen and even fierce competition time is money, and to waste the former is to waste the latter; but too much and too intricate traffic involves the loss of both. If all streets were equally crowded the difficulty would be vast; but while some streets are overdone with concentrated traffic, others are deserted. Here organisation would be of vast service, and should step in and help to distribute the traffic for which there is ample space, if it were sent into proper streams and channels. I recollect, nearly forty years ago, noticing in Vienna that on one of the bridges the police so controlled and arranged the traffic that all foot passengers going one way were made to use one of the side paths, while the one on the other side of the road was used for persons going in the opposite direction. Such a regulation on a London bridge would cause vast inconvenience and annoyance; but there is no reason why foot passengers should not be directed to keep always on the right side of the footpaths, or take the consequences if they got jostled and pushed by persons coming in the opposite direction, who obey the regulation and keep on the side that they are entitled to be on.

SUMMARY.

To sum up the impressions and the results of an inquiry and investigation such as I have had the honour of reading before this critical and distinguished audience, I will again observe the headings into which I have divided up the subject.

As regards the retrospective exhibits, the contributions of drawings, engravings, woodcuts, lithographs, and photographs from England were, for variety, completeness, and condition of preservation, of a most important and illustrative character; useful and instructive to the general public, and invaluable to the historian, the literary man, and the practical mechanic, as showing the means and methods of transport by land, unknown to a large majority of the present generation, and in common use before the establishment of railways.

In carriages for private use those exhibited by France show little progress or improvement in the eleven years since 1878; in some carriages the proportions and outlines are inharmonious, while the Belgian, Dutch, Hungarian, Spanish, and Italian carriages show great improvements on previous exhibits.

England was not represented by any of the carriage manufacturers of high repute and celebrity, a circumstance to be regretted on such occasions; but until suitable accommodation is provided (such as French carriage builders always exact as a condition of contributing) they do wisely not to send their products to be placed under unfavourable conditions, or where they would of necessity attract unfavourable comparisons with other carriages of less merit, but shown to advantage.

The best carriages now produced in England excel all others in elegance of outlines, well-adjusted proportions, suitability and comfort for their intended use, arrangement and shape of parts to obtain the maximum of strength with the minimum weight of materials, durability, freedom from noise, and easy running.

The public carriages of Paris are organised on a totally different system to those of London, are more strictly controlled by the municipality, but on the other hand enjoy a monopoly within certain limits that give the joint stock companies that work them a stability that has many advantages to offer to capitalists, their workmen, and also to the public. A large expenditure on suitable buildings and machinery plant and organisation is better secured under such conditions than under the system usual in London, when sudden and rival competition tends to cause heavy losses, which there is a very considerable temptation to make up when opportunities offer. It would take up too much of your time to discuss the whole policy of the Paris and London system—one tending to completeness, but also with a tendency to stagnate; the other crippling thoughtful and complete organisation, but tending to progress through rivalry and competition.

I have given you some account of the manufacture of carriages in Paris for the public service, of standard sizes, and with all the parts interchangeable.

This has been rendered possible by the Paris system of limited and controlled concessions and monopoly for a given number of years—much in the same way as our great railway companies are empowered by Parliament to do certain things under defined conditions, and carry on traffic for the service of the public and for their own advantage.

Thus, with stability and conditions to employ capital advantageously, great establishments have been designed, acquired, and organised in a most thoughtful manner, with a view to order, efficiency, economy of labour and materials, with a result that to a mind capable of appreciating such efforts of skill, intelligence, industry, and perseverance, is most pleasing.

Conditions like these attract such capable administrators as M. Bixio, the President of the Paris General Cab Company, who has reason to be proud of the good order that reigns throughout the great organisation he controls with such apparent ease.

The details I have given in regard to the preparation of the forage for the 12,000 horses of the Paris General Carriage Company, have, I hope, impressed you with the great service that has been done for some owners, not only in France but in other countries, by such scientific, exhaustive, and expensive experiments as have been made by this company under the auspices of M. Bixio.

The conditions under which the experiments were tried may not be an absolute test of what would result in England, where the conditions of work, rest, food, &c., are so extremely different, but a foundation has been laid for experiments and comparison which may in the near or distant future lead to economy and advantages to other countries besides France; and the pleasure with which M. Bixio shows all those works, arrangements, results, and experiences enhances the good will and thanks he deserves for undertaking so valuable a series of investigations.

Another point to which I have asked your attention, is the large amount of unnecessary traffic in our London streets, and the great saving that would be effected in various directions by the establishment of local markets in suburban districts, whereby the collection of food articles to a centre before distribution would be avoided. The larger the city, the greater would be the saving effected in this way; and Paris, which is so much smaller than London, has in some measure obtained relief for its traffic in the manner I have described.

Having given full information on the technical schools in Paris, it only remains for me to say that there, with about half the population, they have a larger number of students attending the technical classes. It is true that they have been longer established than with us, but our population increases much faster than that of France, and we have need to produce manufactured goods in abundance, in order to exchange for food supplies, of which our own country cannot supply enough.

I have drawn your attention to the rules of the trade union in Paris relating to technical education. If the English trade unions would add such rules to their existing ones they would tend to increase the number of students attending the technical classes, do good service to their sons and young relatives, tend to increase the prosperity of their country, and with it their own, and render the rising generation more fit to make good use of the extended suffrage they now enjoy, and more valuable, and therefore more respected members of society.

But however zealous, and however successful we may be in improving the organisation of the carriage-building industry of our country, we shall still be at a disadvantage with foreign competitors, unless public opinion comes to our aid to abolish that survival of an obsolete fiscal system, the carriage-tax. While the taxation of carriages remains what it is, and Government officers make periodical visits to carriage manufacturers to inspect Government books, and make inquiries on the entries required to be made, it is necessary that the public should know that under our so-called free trade system there are a few glaring exceptions.

The tax has restrained the demand and desire for carriages among us, has accumulated large numbers of old vehicles in the hands of the makers, locked up their capital, increased their expenses for rent, rates, taxes, and caretakers, drawing away their attention from improvements and inventions, from the necessity of devoting so much time and attention to converting the carriages, taken as part payment for new ones (instead of money), into actual cash, which in other countries is at once available for payment of wages, material, rent, and other expenses, and freeing the makers from the incessant work and watchfulness necessary to turn their exchanged stock into money to provide the wages and rent fund.

I cannot but apologise for the length to which my paper has extended, for whereas when I was asked to write on the subject I hesitated lest there should not be matter enough to detain you for an hour, when I really commenced, the matter seemed to grow rapidly, and instead of too little matter, I find it difficult to say all that might interest you, or be of some little advantage to my fellow countrymen, in the time at my disposal; I have therefore to thank my audience for the patient attention bestowed on my paper.*

DISCUSSION.

The CHAIRMAN said this paper was based on the Paris Exhibition, and Mr. Hooper had well pointed out that the English carriage builders had not a chance of competing fairly there, for the reasons named; but, putting that aside, the carriage artists were able to send designs, and he understood that they compared very favourably with the production of French artists. No doubt in some details the French ran us very close, and perhaps even surpassed us, but on the whole he thought there could be no doubt that the English took the lead in carriage building. To begin with the more elegant kinds, he always thought a barouche was the prettiest carriage you could have, and it gave more scope to the builder to show his taste and skill than almost any other, and he had never yet seen a French barouche come up to an English one, though he had seen smaller carriages, especially victorias, very excellent. However, he did not want to make comparisons between the two countries, but he did not want English manufacturers to be surpassed by any foreign nation. English builders were under the great disadvantage that they had not a system of State-supported technical education such as prevailed in France and other countries. The next matter which struck him was the system under which the public carriages belonging to a large Paris company were all built to precisely the same pattern, so that any portion which was damaged could be replaced in a moment. He did not see why that system should not be adopted in this country by Mr. Hooper or anyone else, and applied to private carriages as well as public vehicles. Now-a-days the two great desiderata in a carriage were lightness and durability, and according to his experience both these points had been much improved of late years, and at the same time the draught was brought nearer to the horses than it used to be. The traffic again was another point of great interest and importance, for he sometimes shuddered to think what would happen in another ten years, or certainly in twenty, if the omnibuses went on increasing as they had done lately. You saw four, five, and six following each other in close succession all loaded, and it was a marvel to him where all the horses slept, and where all the vehicles were put at night. He had also admired the way in which the makers had improved them to meet modern requirements. The driver was now brought right over his horses, the omnibuses were more commodious, not only inside but out, so that even ladies clambered up to the top quite easily, and sat in comfortable chairs when they got there, and though he had not been in Paris lately, he doubted if their omnibuses were equal to ours. He should like to see the large three-horse omnibuses discarded, however, for they were really a nuisance. The traffic was, no doubt, admirably managed by the police, but he should like to see them exercise a little more authority in keeping heavy traffic to the kerb. Unless something more were done soon, people would have to give up driving carriages at all in London, and everyone would have to ride in the omnibuses.

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* The labour of collecting information on various matters referred to in this paper has been much lightened by the kind and ready assistance of the following gentlemen, to whom my grateful thanks are due:—M. Bixio, president of the General Carriage Company, Paris; M. L. Dupont, Paris; M. Brice Thomas, professor of the technical class of the Syndical Chamber of Carriage Builders, Paris; the manager of the manufactory of the General Omnibus Company, Paris; the Commissioner of Police of the Metropolis; Mr. K. B. Murray, Secretary of the London Chamber of Commerce; Mr. Longhurst, Hon. Sec. British Chamber of Commerce in Paris; the Secretary of the Glasgow Tramway Company; Messrs. Tilling; Mr. Wilkes, manager of the forage department of the General Omnibus Company, London; Mr. Crane, manager of the carriage manufactory of the General Omnibus Company, London; Mr. Spencer, secretary of the Shrewsbury and Talbot Cab Company, London; Messrs. Clinch, job masters, London; M. Sire, agent of the Northern of France Railway in London; Mr. John Robertson, for many years a teacher of the three technical classes in London, and a former student in the technical class in Paris.

Lord SUFFIELD said this paper was very interesting, and worthy of every one's consideration. He was glad to find that England still maintained her supremacy in this matter, though the French had done some excellent work. We had workmen in this country, and all the materials and intelligence, and we ought to retain the supremacy in carriage-building we had always held. Looking at the painting on the wall of an ancient chariot, one could see that we had vastly improved, but still a carriage was drawn on the same principles as then prevailed. He had lately had a private omnibus built on the lines which had been indicated, bringing the horses nearer to their work, so as to make the traction lighter, and that was one of the most important modern improvements.

Mr. ROCK, after expressing the pleasure with which he head heard the paper, said the Chairman's suggestion about making the parts of private carriages interchangeable was hardly practicable, as English carriage users generally had their own ideas of what a carriage should be, and liked a little individuality about it. This system, therefore, though it might extend to the axletrees and a few other details, could not go much farther. The improvement in omnibuses had followed in great measure from the improvement in the streets of London. Many years ago he introduced some improvements with the view of giving more room inside an omnibus without increasing the external dimensions, which was then impossible on account of the narrowness of the streets, and his principle was generally adopted, so that now there was more room for passengers to pass one another than was formerly the case; but now the streets were wider, larger omnibuses were quite practicable.

Mr. MANUEL asked if Mr. Hooper could give an assurance as to the safety of those vehicles with the garden seats on the top. He was not quite sure that the constructors were quite sound in regard to where the load should be. The summer was coming on, when everyone rode outside, and they were often empty within, and it seemed to him that then the centre of gravity must be rather high. Taking that in connection with the violent oscillations which resulted from the wheel skidding on a tramline, he thought there was some doubt about the stability of the vehicle. Not long ago there was a serious accident from an omnibus overturning, but he did not remember whether or not that was due to any structural defect.

Mr. CRANE (of the London General Omnibus Company) said the accident referred to arose from an axletree breaking, and he did not know a single case of an omnibus turning over, except from that cause. Axletree makers were not as careful, he was afraid, as they should be, in seeing to the quality of the material and workmanship they sent out; and he thought they were responsible for most of the accidents. The General Omnibus Company were very chary about introducing the garden seats when they first came out; but as they became popular they adopted them, and had gone on for five or six years without having an accident; that was, no doubt, owing to the improved state of the roads, for if they had to travel over the old roads he should not like to answer for their safety. A more modern omnibus still had been brought out with a much narrower track, constructed, they were told, on much safer principles, though some of them hardly believed it. Still they did not turn over; but the older-fashioned ones, with the wheels outside the body, must be still safer. He had been much pleased to hear about the technical schools in Paris, and could not agree with those who said that our carriages were so much superior to the French. He considered the Paris carriages were a grand sight for an English coachbuilder, who might learn much from them, especially in the steel and iron work. He never saw better iron work in his life. A good deal of French ironwork had come into London during the last few years, and in soundness, shape, and durability it was all that could be desired. The company had used a good deal of it, and found it most reliable. He certainly thought the French had some trade secrets connected with smithing which it would be well worth trying to discover. No doubt much of this was due to the technical classes, and if our trade was to hold its own, more time and pains must be spent on the education of the young workmen. He was connected with one of the largest classes which Mr. Hooper had mentioned, and with the exception of

Mr. Hooper himself, and one or two other coachbuilders, they had no support from the carriage-building industry. The trade unions of London did not give any certificate of ability, and if a man came and said he was a trade unionist it did not show he was a good workman. As he understood, the Trade Union of Paris did ensure to a certain extent that its members should be qualified workmen, and if the London union would do the same, no one would object to paying the wages asked. It would be a great advantage both to the workmen and masters that the man should carry his credentials with him, like a professor or a medical man. The monopoly of the Paris Omnibus Company had no doubt produced some good results, but he did not think the omnibuses in Paris were any advance on those of London. They were cumbrous things with three horses, such as a few in London, but there were only four left, and he did not exactly know why they were retained. One important point which had not been noticed, was the shoeing of horses; we did not seem to have got a proper shoe at present.

Mr. H. TRUEMAN WOOD said he could entirely endorse what Mr. Hooper had said about Exhibitions. He thought both our Government and our traders made a great mistake in not sufficiently regarding the importance of these international competitions. No doubt one cause of the difficulty which English manufacturers found in competing with foreigners was that the individual manufacturer had really to compete with the collective or selected exhibits of the whole of the foreign trade. There was no selection made of English representatives, whereas at Paris there was a stringent selection of those who were allowed to compete as representatives of French carriage building and other industries. This was a matter for the various trades to consider. It was not the individual exhibitor alone who reaped the benefit; it was quite as likely to go to his competitor in his own country. He might attract notice to the English make, and the business might go to his rival. The different trades ought to consider this, and in any future foreign exhibition, see if they could not sink their individual rivalries, and agree to represent not individual interests but the particular trade of England. With regard to the actual expenditure incurred by French and English exhibitors, he did not think there was a very great difference, because Mr. Hooper said the average cost to the French manufacturer of showing a carriage was £20, and as the charges made to English exhibitors were 5s. per square foot, that would represent 80 square feet, which was about the space required to show a carriage.

Mr. J. CARNEGIE (Carter, Paterson and Co.) said one important point in connection with the traffic was the condition of roads and streets. The slippery condition of the wood and asphalte pavements after a slight shower was a constant source of danger and difficulty, and an association had been started with the object of getting those kinds of pavement replaced by granite cubes. If that were done, he was sure the vehicular traffic would get along much better.

Mr. BENNETT asked if Mr. Hooper could state whether iron was found to be preferable to wood for panels.

Mr. GORDON HARRIS referred to a recent patent for inserting lead plugs in the asphalte, which obviated the slipperiness of the surface.

Mr. WILLANS suggested that the street traffic would be rendered much more manageable if the rule adopted on London-bridge were enforced generally, and all heavy traffic going at a walking pace were obliged to keep close to the kerb. He was obliged to ride about a great deal, and he constantly found heavy vans and waggons occupying the middle of the road. He had noticed this even on the Embankment early in the morning.

Mr. MACLACHLAN thought it would be a still greater improvement if the heavy traffic were as far as possible kept out of the main thoroughfares, and sent along the bye streets. With regard to the construction of carriages, though they were improved in some respects, he feared they had gone back in others; for instance, with regard to ventilation, they used to have sliding windows, which were now almost disused; perhaps the greater width inside had been obtained at the sacrifice of the window-boxes; but he did not see why an omnibus should not be as wide as a tram-car.

Mr. HOOPER said the Institute of British Carriage Manufacturers had attempted to do something in the way of introducing standard sizes for the various parts, and had gone a certain distance, but the difficulties were very considerable. They consulted Sir Joseph Whitworth, who was extremely interested in the matter, and gave them every information as to the difficulties he had to encounter in introducing the uniform pitch of screws and the accurate measurement of surfaces which had done so much for engineering. They had laid down standard sizes for axletrees, though this was a matter of great difficulty because of the extreme accuracy required, and the difficulties were not yet all overcome. They had also suggested standard proportions for the shafts of two-wheeled, and possibly for four-wheeled, vehicles which, if disseminated throughout the country, would enable coachmakers to make the shafts of proper proportion for the horses intended to be used in them. Lamp fittings also had been regulated to certain sizes, so that, by quoting the number on the socket, a pair of lamps could always be obtained to fit, and lately a series of standard sizes had been laid down for the brake blocks, which had a great deal of wear, so that they could be replaced in any part of the world without difficulty. It was quite true that the improvement in carriages had followed on the improvement in roads, and as the roads were further improved so would the carriages. With regard to the garden seats of some modern omnibuses, he must admit that he looked upon them at first with some trepidation, but he was convinced that if their stability depended on the weight of the under-part keeping them on the ground, there was not much to fear. Others had since appeared with a much narrower base, and he trembled still more, but they had gone safely through the ordeal, and though the track was very narrow, the springs were very wide and very stiff, and hitherto they had preserved their equilibrium. So long as the paving of the streets was kept in thorough repair, very likely these lighter vehicles with their top loads would be safe; but it all depended on the condition of the street surfaces, for any sudden oscillation would be a source of danger. As Mr. Crane had said, the axletree was the principal source of danger, and it could not be too strongly impressed on axletree makers how important it was to use only iron of the best quality, and that the greatest possible care should be bestowed on that part of a carriage which, of all others, sustained the most severe strain. With regard to technical training, he could not impress too strongly on English workmen the desirability of encouraging technical classes, which they could do by their influence at least. If it had not been for the enthusiasm of some of the teachers, the classes could not have succeeded as they had done; they had struggled on for some years under many difficulties, but he hoped the time was coming when all parties would see the immense importance of giving a better training to the future workmen of this country. He was glad to hear from so high an authority as Mr. Wood that he agreed with him with respect to the importance of international exhibitions. When he was at the exhibition at Barcelona he found the English court almost half empty, and he heard it remarked by foreign visitors how the English were overlooking their own interests. There were difficulties no doubt in connection with the Paris Exhibition, and probably all that was possible was done; but when foreign exhibitors were supported by the prestige of their Governments, England was placed at a disadvantage in these international contests, and he hoped manufacturers would see that the time had come when a different policy should be pursued. With regard to iron panels, there was a particular reason for using them in France, where the heavy duties placed on all raw materials prevented to a great extent the use of mahogany, which possessed all the qualities desirable in a good panel. The French had used poplar and walnut wood, but it was not to be compared to mahogany, and the French found iron the best substitute. The climate was drier there, but there was a tendency in these panels to produce vibration which was unpleasant. The regulation of the traffic was one of the most important questions for Londoners at present. The police authorities did their best, but if the regulations were made more strict with regard to the heavy traffic, a better result might be obtained. The ventilation of omnibuses was very important, on the ground of health, and he was inclined to think that coincidentally with the improvement of the accommodation outside, there had been some tendency to curtail the ventilation, and he would recommend Mr. Crane to give this subject his attention. He did not claim to be any authority on road surfaces, but he knew that asphalte was very slippery under certain conditions, and thought the Boards of Works had done well in replacing it by wood, but he had rather not give a decided opinion on the subject.

The CHAIRMAN, in proposing a vote of thanks to Mr. Hooper, alluded to the carriage tax, and expressed a hope that as the Chancellor of the Exchequer had a surplus, he might take it off in his new budget.

The vote having been passed unanimously,

MR. HOOPER, in response, said he had referred to the question of the tax on carriages in his paper. He was quite satisfied that the removal of this tax and also that on silver plate would tend greatly to the improvement of the respective industries, and would especially benefit the workmen engaged in them, by liberating the capital now locked up in accumulated stock of exchanged carriages and the expenses of warehousing them, and rendering it available for wages to a larger number of skilled artisans.

Obituary.

DUKE OF MANCHESTER, K.P.—His Grace the Duke of Manchester, Vice-President of the Society of Arts, died at the Hotel Royal, Naples, on Friday evening, 21st inst. William Drogo Montagu, seventh Duke of Manchester, Viscount Mandeville, and Baron Montagu of Kimbolton Castle, St. Neots, Huntingdonshire, and Tanderagee Castle, county Armagh, was the eldest son of George, sixth Duke of Manchester, an officer in the Royal Navy, by his first wife, Millicent, daughter of General R. B. Sparrow, and was born at Kimbolton Castle on October 15th, 1823. He was educated at the Royal Military College, Sandhurst, and entered the army as an ensign in the 11th Foot Regiment in 1841. He was aide-de-camp to Sir Peregrine Maitland, Governor of Cape Colony, from 1843 till 1846. He became a captain in the Grenadier Guards in 1846, and retired from the army in 1850, being appointed major of the Huntingdon Militia in 1852. From 1865 till 1882 he was lieutenant-colonel of the Hunts Light Horse Volunteers, and hon. colonel of the corps from July, 1881. He was a magistrate and deputy-lieutenant for Huntingdonshire, was a Lord of the Bedchamber of the late Prince Consort from March, 1852, till January, 1853, and was holder of the Order of the Iron Cross of Prussia. In 1847, he unsuccessfully contested Westminster, but was elected for Bewdley in 1848. He continued to represent this borough till 1852, when he was returned for Huntingdonshire a few weeks before the general election. He was again returned at the ensuing election. In 1855 he succeeded to the family honours. He travelled much in the colonies, and was President of the Royal Colonial Institute.

THE LIBRARY.

The following books have been added to the Library since the last announcement:—

Barlow, Crawford, B.A.—The New Tay Bridge; a Course of Lectures delivered at the Royal School of Military Engineering at Chatham, 1888. (London: E. and F. N. Spon, 1889.) Presented by the Author.

Bindings, Rubbings of Old, in the Possession of Henry S. Richardson. Presented by Henry S. Richardson.

Cowe, Rev. James, M.A.—The Meteorological Register, kept at Sunbury Vicarage, Middlesex, 1795-1839. (London: 1889.) Presented by William Horncastle.

Duncan, Edward.—British Landscape and Coast Scenery and Marine Painting. (Vere Foster's advanced Water-colour series.) (London: Blackie and Son.) Presented by the Publishers.

Ellis, Thomas, M.P., and Ellis Griffith.—A Manual to the Intermediate Education (Wales) Act, 1889, and the Technical Instruction Act, 1889. (London: National Association for the Promotion of Technical and Secondary Education.)

Fleming, J. A., M.A., D.Sc.—The Alternate Current Transformer in Theory and Practice. Vol. I. The Induction of Electric Currents. (London: *The Electrician* Printing and Publishing Company, 1889.)

Groves, Charles Edward, F.R.S., and William Thorp, B.Sc.—Chemical Technology. Vol. I. Fuel, by E. J. Mills, F.R.S., and F. J. Rowan. (London: J. and A. Churchill, 1889.) Presented by the Publishers.

Harris, H. Graham.—Continuous Brakes. (Chatham: Royal Engineers Institute, 1889.) Presented by the Author.

Medical Annual and Practitioner's Index, 1890. (Bristol: John Wright and Co.) Presented by the Publishers.

National Association for the Promotion of Technical and Secondary Education, Technical Education in England and Wales: a Report to the Executive Committee. (London: 1889.)

Nisbet, Ethel.—Flower Painting for Beginners. (Vere Foster's Water-colour Series.) (London: Blackie and Son.) Presented by the Publishers.

Paris Universal Exhibition, 1889. Reports of Artisans selected by the Mansion-house Committee. (London: C. F. Roworth, 1889.) Presented by Alderman Sir James Whitehead.

Philipson, William.—Prize Essay on the Suspension of Carriages. (New York: Hub Publishing Co.) Presented by the Author.

Platt, James.—Men and Women. (London: Simpkin, Marshall and Co., 1890.) Presented by the Author.

Poyser, Arthur W., M.A.—Magnetism and Electricity. (London: Longmans, Green and Co., 1889.) Presented by the Publishers.

Quilter, James Henry.—The Trimming and Finishing of Hosiery and Hosiery Fabrics. (Bradford: 1889.) Presented by the Author.

Ripper, William.—Steam. (London: Longmans, Green and Co., 1889.) Presented by the Publishers.

Rothschild, M. D.—A Handbook of Precious Stones. (New York: G. P. Putnam's Sons, 1890.)

Shaw, George.—Revived Guild Action; with a History of the Movement for the Registration of Plumbers. (London: Simpkin and Marshall, 1889) Presented by the Author.

Simpson, William.—Handbook for Coach-painters, edited by G. A. Thrupp. (London: Cooper Bros. and Attwood, 1888.) Presented by John Philipson.

Watts' Dictionary of Chemistry, revised and entirely rewritten by M. M. Pattison Muir, M.A., and H. Forster Morley, M.A. Vol. II. (London: Longmans, Green and Co., 1889.) Presented by the Publishers.

Whitaker, W., B.A., F.R.S.—The Geology of London, and of part of the Thames Valley. 2 vols. (London, 1889.) Purchased.

Whitfield, Edward E., M.A.—Grammar of the French Languages of Business, edited from the German of Dr. Rudolf Thum. (London: Hachette and Co., 1889.) Presented by the Author.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

Papers for Meetings after Easter:—

APRIL 16.—TALBOT B. REED, "Old and New Fashions in Typography." DR. GARNETT, Keeper of the Printed Books in the British Museum, will preside.

APRIL 23.—WILLIAM WHITAKER, F.R.S., "Coal in the South-East of England." ARCHIBALD GEIKIE, LL.D., F.R.S., will preside.

MAY 7.—DR. PERCY F. FRANKLAND, "The Aim and Scope of Higher Technical Teaching."

MAY 14.—ELIHU THOMAS FLEMING, "Electro-Magnetic Indicator Experiments."

FOREIGN AND COLONIAL SECTION.

Tuesday afternoons, at Five o'clock:—

APRIL 22.—SIR JOHN STOKES, K.C.B., "The Danube and its Trade."

A. LASENBY LIBERTY, "The Industrial Arts of Japan."

C. G. WARNFORD LOCK, "Gold Mining in Hungary."

INDIAN SECTION.

Thursday afternoons, at Five o'clock:—

MAY 22.—SIR J. THEODORE HOPE, K.C.S.I., "The Rationale of Indian Railways." The MARQUIS OF RIPON, K.G., will preside.

[The Meetings of this Section will in future be changed from Fridays to Thursdays.]

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock:—

APRIL 15.—C. PURDON CLARKE, C.I.E., "Modern Indian Art." Sir GEORGE BIRDWOOD, M.D., K.C.I.E., C.S.I., will preside.

MAY 13.—Prof. W. C. ROBERTS-AUSTEN, F.R.S., "The Use of Alloys in Art Metal-work."

CANTOR LECTURES.

Monday evenings, at Eight o'clock:—

A. H. CHURCH, M.A., F.R.S., Professor of Chemistry in the Royal Academy, "Some Considerations concerning Colour and Colouring." Three Lectures.

LECTURE III.—MARCH 31.—Balance, proportion, and distribution of colour. Counterchange and interchange of colour. Colours of natural and artificial materials. Decorative and pictorial colour. Colour in relation to architecture and sculpture.

POPULAR LECTURES.

Saturday afternoons, at Three o'clock:—

Professor VIVIAN LEWES, "The Atmosphere." Four Lectures.

LECTURE IV.—MARCH 29.—Local impurities in air. Germs and the propagation of disease. Decay. Purification of the air by rain and oxidation. Ozone. The air of enclosed spaces, and the amount of fresh air required for health. Ventilation. The formation of air currents. Draughts. The effect of our methods of heating and lighting rooms upon health. Conclusion.

The regulations for admission will be the same as for the Cantor Lectures, each member having the privilege of admitting a friend.

ADDITIONAL LECTURES.

Thursday evenings, at Eight o'clock:—

LEWIS F. DAY, "Design applied to Wood-Carving." Three Lectures.

May 1, 8, 15.

The regulations for admission will be the same as for the Cantor Lectures, each member having the privilege of admitting a friend.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MARCH 31...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Prof. A. H. Church, "Some considerations concerning Colour and Colouring." (Lecture III.)

National Indian Association, Westminster Town-hall, S.W., 5 p.m. Mr. Frederick Harrison, "Some Great Books of History."

Drawing Society, Conduit-street, W., 8½ p.m. Mr. W. Holman Hunt, "The Proper Mode of Study and Exercise in Art."

Actuaries, Staple-inn-hall, W.C., 7 p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Colonel Gourand, "The Phonograph."

Society of Chemical Industry, Burlington-house, 8 p.m. Election of officers. 1. Dr. W. P. Squire, "A Separator for Solids and Liquids." 2. Mr. H. Langbeck, "Wool Washing, Wool Fat, and Products."

TUESDAY, APRIL 1 . Central Chamber of Agriculture (at the HOUSE OF THE SOCIETY OF ARTS), 11 a.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. John Robinson, "Barry Dock and Railways."

Pathological, 20, Hanover-square, W., 8½ p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Mr. C. M. Woodford, "Further Remarks on the Fauna of the Solomon Islands." (With photographic illustrations.) 2. Dr. R. W. Shufeldt, "Contributions to the Study of *Heloderma suspectum*." 3. Dr. A. Günther, "Description of a new Species of Deep-Sea Fish from the Cape (*Lophotes fiskii*)."

WEDNESDAY, APRIL 2...Cymmrodorion, 27, Chancery-lane, W.C., 8 p.m. Prof. J. E. Lloyd, "Welsh Place Names."

Entomological, 11, Chandos-street, W., 7 p.m. 1. Mr. Edward Meyrick, "The Classification of the Pyralidina of the European Fauna." 2. Mynheer Pieter C. T. Snellen, "A Catalogue of the Pyralidæ of Sikkim, collected by the late Otto Möller and by H. J. Elwes." (With notes by Captain H. J. Elwes.) 3. Prof. J. O. Westwood, "Notes on certain Species of Cetoniidæ of the Section Goliathides."

Archæological Association, 32, Sackville-street, W., 8 p.m.

Obstetrical, 20, Hanover-square, W., 8 p.m.

THURSDAY, APRIL 3...Linnean, Burlington-house, W., 8 p.m Prof. W. K. Parker, "The Morphology of the Gallinacea."

Chemical, Burlington-house, W., 8 p.m. Mr. G. H. Picton, "Note on the Hydrosulphides."

Mathematical, 22, Albemarle-street, W., 8 p.m.

FRIDAY, APRIL 4 ..Good Friday.

SATURDAY, APRIL 5...Foremen Engineers and Draughtsmen, Cannon-street Hotel, E.C., 7½ p.m. Mr. J. J. Pike, "Early Engineers."

Journal of the Society of Arts.

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FRIDAY, APRIL 4, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

POPULAR LECTURES.

The fourth and last lecture of the course on the "Atmosphere" was delivered on Saturday afternoon, 29th inst., by Professor LEWES, who showed the action of local impurities, *i.e.*, those foreign substances which are only found in the air where the causes which gave rise to them exist. He pointed out the enormous importance of the organisms and germs present in air in causing decay and putrefactive changes, which tend to clear away waste animal and vegetable matter, and to again resolve it into simpler compounds from which organised matter can again be built up.

In nature the air is kept in a condition fit to support life by circulation due to air currents and to diffusion, by the growth of vegetation, by the oxidation of waste matter by oxygen and its more active allotrope ozone, and finally by the cleansing action of rain; but although these suffice in the open air, in enclosed spaces the action of nature must be aided by artificial currents, so arranged as to change the air without producing draughts. Ventilation may be defined as the art of supplying fresh air at a rate of flow not greater than eighteen or nineteen inches per minute, and in sufficient quantity to reduce the carbon-dioxide present to a maximum of six volumes in 10,000 of air.

In our dwelling-rooms the processes of respiration and combustion form carbon-dioxide, and also load the air with water vapour and organic impurities; but although at equal temperatures carbon-dioxide is heavier than air, when formed in these processes, it is expanded by heat, and therefore rises, and should be withdrawn from the upper portion of the room before it has time to cool and descend. The lecturer concluded with a short consideration of the effect of various methods of heating and illuminating on the air of rooms.

A cordial vote of thanks to the lecturer for his interesting course of lectures was passed on the motion of the CHAIRMAN.

CANTOR LECTURES.

Professor A. H. CHURCH, M.A., F.R.S., delivered the third and last lecture of his course, entitled "Some Considerations concerning Colour and Colouring," on Monday evening, 31st March.

On the motion of the CHAIRMAN, a cordial vote of thanks to the lecturer was passed.

The lectures will be printed in the *Journal* during the summer recess.

Proceedings of the Society.

APPLIED ART SECTION.

Tuesday, March 25, 1890; WILLIAM SIMPSON in the chair.

The paper read was—

ENGRAVING IN WOOD; OLD AND NEW.

By W. J. LINTON.

CONCERNING THE USE OF LINES IN ENGRAVING.

My argument is concerning the use of lines in line engraving. Of what use and of what value are lines in engravings which are altogether done in lines?

I confine myself to my own art, engraving in wood; but my argument may be also applicable to engraving in steel or copper, and not without interest as regards art in general. To show the use and value of lines in a line engraving may at first appear unnecessary, but indeed there are engravers and critics who seem to require some teaching.

Not certainly the inventors of line engraving, but the beginners of the art of line engraving in wood, were Thomas Bewick and Robert

Branston. Branston died in 1827, Bewick died a year later, in which year I was apprenticed to Bonner, a nephew and a pupil of Branston. Better engravers than even Bewick himself were two of his pupils, Nesbit and the painter Clennell. And Branston's greatest pupil, John Thompson, we have always recognised as the master of our art. These are the old engravers of whose work I have to speak. Passing over my own period of half a century, it is their work which I would compare, or contrast, with what has been called a new departure, recent work in America, coming into fashion also here. I do this in the interest of art generally, especially in the interest of my own branch of art, engraving in wood. I am sorry that I can bring only statement and argument to bear upon the question, as it is impossible to exhibit specimens showing the differences of old and new. I can only endeavour by description to make the matter clear to you.

I mean to speak of the old work, that of the men I have named (named as representatives) as good work; of the new work (notably American) as bad. Good or bad in this: the old work was characterised by the expressiveness and beauty of its lines; the new work is remarkable for the absence and neglect of beauty or expression.

Bewick's line was not always good; but you cannot look at an engraving by Clennell or Thompson without seeing at once that the engraver was an artist. Forgive so broad an assertion. There are eyes which cannot see, and not a few professed critics are really purblind, some sightless. Let me say only that any one qualified to judge of an engraving would not fail to see in the work of Clennell or Thompson that the engraver was an artist; that is to say, that he had knowledge and purpose in his work, that he used his brain as well as his hand, that every touch or line of his graver was governed by thought, was as purposeful and sure as if he had drawn it with a pencil; that he did indeed draw it with his graver. I want you to understand this as the primary essential, the one necessary qualification of good engraving; this as absolutely required, that the engraver in every line—aye! in every line—shall have forethought and intention, and (making allowance for some inefficiency in all men) that he shall do what he intended. I think this holds good in all art, whether the graver, the pencil, or the brush be the instrument in the artist's hand. On this principle the old men worked. They had some inkling of what may perhaps be asserted without fear of cavil, that a work of art should be artistic throughout. As their work had to be done in lines, they perceived that it might be worth while to consider with what lines, so finding that some lines were fit for certain purposes or for parts of an engraving, and some not fit, so reaching at last to a preference of beautiful and harmonious lines and the avoidance of lines ugly and offensive. And this seems to me the singular ground upon which all good line engraving in wood or copper has been and must be based. So based, I find in the engraving of the old time to which I refer, that the lines were well considered, showing that the engraver always deemed them of importance. Differences of line there were; white line characterised the Bewick school. What may be called the drawing of the subject—bird, landscape, figures—was rendered by white lines, the graver incisions in the wood, the black surface of the block from which the print was taken being as it were a black board on which the picture was by the graver expressed and drawn in white. Thompson's work rather imitated copper, he—if a broad distinction had to be made—thinking and caring more for the black lines he left on the surface than for the lines he cut, but caring for both.

There, I take it, is the peculiar excellence of that old-time work; the full understanding that a good line engraving is the representation of a picture—a portrait, a landscape, or anything else—by beautiful lines, lines chosen and well adapted to give the forms, the lights and shadows, the perspectives, and in some cases the very substances, of the picture represented. I regret that I cannot show you examples in proof; you must seek them for yourselves in such books as you can get opportunity to examine. You need such examination to enable you to understand what good engraving is.

Do not make the common mistake of supposing an engraving must be good because you like the subject and find the general effect to your mind. If you would know what engraving is, you must judge of it quite independently of the subject or the designer. You may be satisfied with the picture before you in this month's magazine and not care anything about the technical excellence of the engraving. If so I have nothing to say to you except this—Do not talk about it as an engraving!

I gather this from my experience as an engraver: that certain lines are more fit than others, consequently that a consideration of fitness is of importance. A rough line will better represent a rough surface; delicate contours should be modelled by smooth and flowing lines. Also there is a perspective in the use of lines. And I dare to assert as beyond controversy that fitness and beauty are requisites of art. I know that all forms, all rules, have a tendency to become only formal, conventional; but that is no reason for not considering and determining their worth; and conventionalism may not be best avoided by merely running away from it. I am not insisting upon certain set lines, nor indeed on any lines at all. I can be content without lines. I admire mezzotint and aquatint, and also some new photogravures of a similar character. Only, when we must have lines let them be good lines! (As an artist, can I demand less?) good lines, well considered, fit, expressive, and (may I not add?) pleasant to look at; lines that will tempt a second glance, lines to satisfy the learned lover of engraving as a distinct art, lines such as I find in the works of my old wood-engravers, such as I find also in the best works in copper, such works as those of Sebald Beham of old time, and of Milton and Sharp (landscape and portraiture) of later period.

Coming now to the new style of engraving, I quarrel with it for its want of art. The engravers, being only line engravers, do not appear to know or to care anything about lines. They neglect the study of line, and show an utter indifference to line values. Take the two most notable magazines which brought into vogue this now much-admired and much-praised kind of work, admired by an ignorant public, and praised by professed critics who ought to know better; I refer to the *Century* and *Harper* for my examples. I dare to say that, with few occasional exceptions, there is no art in them. Generally clever and pleasing pictures, well-designed, effective, and nearly as good as photographs. Pure photographs, if to be had, would, however, well replace them, and we should then escape the infliction of linear ugliness, and be no longer annoyed and insulted with the pretence of engraving. Do I judge these pseudo-engravings too severely? Once you may look at them, and, not noticing the lines, be satisfied with the general effect, but will any intelligent person look at them a second time to admire the engraver's workmanship? I do not deny their cleverness even as engraving, but the cleverness, the very great cleverness, is only mechanical, there is no art in it. There is no artistic taste nor judgment in the employment of lines; there is no expression in a single line. Colours may be kept; but form is lost; distances are mixed and confused; substances are unnoticed; the combinations of line are ugly and offensive. I speak without the works before me in proof, but they are in everyone's hands. Think of what I say when you look at your next number. Try if you can discover, except in the portraits (strangely engraved by the same men with real regard for fitness and beauty of line)—try if you can discover any lines that have beauty or expression, or giving any sign of intelligence. There is wonderful delicacy, that is delicacy of tone, fineness, thinness of line; the often useless, sometimes most unhappy minuteness is astonishing. I have been surprised at these accomplishments, exceeding sometimes anything I have thought possible in wood engraving. It is the triumphant assertion of mechanical skill. What eyes these men must have! What nicety of hand! But then—I am speaking as an engraver—in the prettiest and most successful of these engravings I seek in vain for evidence that the engraver had any brains, that he could have known or understood the forms he was engraving, that he had any thought of perspective, any perception of differences of substance. In nearly all these cuts foreground objects are on the same plane as those in the background, there is neither air nor distance; sky may be wall, and water may be folds of drapery, for any distinction of linear treatment; and the lines throughout are laid with utter disregard of the things supposed to be represented by them, in seeming ignorance or wilful rejection of all the laws of linear beauty and perspective recognised and cared for by the masters of engraving both in wood and copper. Horizontal lines of a sky are crossed perpendicularly; the rough bark of a tree, a woman's delicate cheek or bosom, a sheep's woolly back, have no distinction of line to denote difference of substance; foreground and extremest distance are cut with the same unvarying fineness; all things stick together, all things are undefined, muddled, confused. Colour and tone may be excellently kept, and the first impression, not noticing the lines, taking the picture only as a clever and tolerably fair imitation of a photograph, may strike one pleasantly; but returning to it, examining it, there will be no satisfaction. It will never give the enduring pleasure of a beautiful engraving. Forgetting the lines altogether, it may be possible to like it, but one will not care to look at it again and again. The more closely it is examined the greater will be the disappointment. Does not that of itself condemn it?

And yet in these same magazines are heads engraved by the same men, engraved with singular appreciation of the beauty of line, and with close attention to that, portraits which by their juxtaposition only make the unredeemed ugliness of figures and landscape the more conspicuous. I can hardly overpraise some of these heads. The drawing is firm and definite, the modelling is good, the flesh does not want for fleshiness, the lines are laid harmoniously, so that in themselves they are a delight to see. Why should this be thought necessary or worth doing in a portrait, and yet be altogether neglected or despised in every thing else? I cannot answer why; but I know that the attention in one case rebukes the inattention in the other.

The laws of line in engraving are not merely the pedantry of the schools. They have arisen out of the very nature of art, and are as absolute and incontrovertible as any other of artistic principles. That every drawn or engraved line should be beautiful is involved in the assertion that art is the expression of beauty. Good work is thorough. To say that a picture should be beautiful is but to say that it should be beautifully done. And, however unaware we may be of the origin of those beautiful fitnesses of line which characterise the works of the greatest engravers, however conventional and arbitrary they may appear, nay, however tiresomely-mannered they may sometimes become in the formality of inferior practitioners, they are yet rules for our guidance, which we cannot neglect or violate with impunity. Haste may excuse departure from them, as in the slighter studies of the great painters we see shadow lines put in merely as memoranda, scribbled in without heed or need of better forming. If the engraver, on whom I am desirous of impressing this law of form, will for himself attempt not a hasty sketch but a careful drawing, such as I will now suggest to him, he will, I think, better understand the matter. Let him draw a hand, a finger, or only the end of a finger-bone; let him draw it with lines only, fine lines, but quickly and freely without scumbling. The first line he draws (or I am much mistaking) will be a circular line, some indication of the round outer form of the bone. Not perfectly accurate in his first line, he will correct it with other lines, also circular. As he goes on shadowing and perfecting his drawing he will observe that, without intention, the general direction of his lines has always had relation to the forms of the bone. In other trials he will find that he can express forms, convexity or concavity, absolutely by direction of lines and without colour. The law here asserted rules everything. In a face or in a tree, in a cloud or in mountain character, the same law obtains.

Colour alone (I mean mere light and shadow) can also represent form, but if that colour has to be got by lines, the law of line comes in absolutely. I do not mean to depreciate the value of tone or of delicacy where wanted. I only contend against exclusive attention to colour and tone, and insist that when you must use lines those lines shall have meaning. An engraving in wood is producible only by lines, and you cannot by any excess of fineness get rid of the lines. Is it not well, therefore, that what must be seen should be good, or, say, at least agreeable? Is it not clear that as all your work is done in lines, the more these lines express or indicate, the more complete and satisfactory will be your work? Shall they not, even by their direction, rather explain or help to explain the shape or substance you have to represent with them than distort or hide it? In the photographic imitations in the *Century* and *Harper*, and elsewhere, all thought of the values of line is abandoned. Whatever the value of colour, of tone, of fineness, does that necessitate an absolute disuse of line? Disuse, for in the cuts I condemn line is not used, it is only put up with, its real use is avoided. It may be that this is wilful. There may be engravers who prefer to have no differential intelligence in their lines. I would still ask them to care a little for some pleasantness of beauty, confessing, however, that I have not much hope of beauty without intelligence.

What is beauty as regards line? To point to examples may be better than to attempt any accurate definition in precise words. Look at free tree growth, the natural untrained interlacing of the boughs and twigs; examine a bird's wing, noting not only the outer form and inner central line of each feather, but also the arrangement of lines throughout; remark that same beautiful line of the feather and the wing, the line ever departing from the confinement of the mere circle in all mountain form. Watch the play and change of line in the stirred sea waves, or at your own hearths observe the varying forms of flame. You will then see, if your eyes have vision, what the lines of beauty are, and learn something of those underlying principles on which, consciously or unconsciously, the lines of great artists have been founded.

I have referred to engravings in copper as examples of line. But it is in the white, the incised line of the wood engraver, that his process is identified with that in copper. White line in wood takes the place of black line in copper. I think that even our great engraver, John Thompson, for all his mastery of line, lost sight of the true principle of work in wood when he departed from the white line of Bewick. In that direction only are we able to show the full capability of wood engraving, in that only can we fully earn the distinctive name of artists.

But the engraver's lines, those recommended for study, are so conventional. The very language of art is conventional. Are we, therefore, to be content with the mere ejaculations (not to be called speech) of the careless impressionist? Grammar is conventional, based however, on certain laws of language, studied, and to some extent known, if not always absolutely determined. The laws of poetry are conventional. Men may eccentrically escape from them, but it is not given to every one to invent a new rythmic system; and so, though I or any other engraver may be free to try any experiments in line, it may not be certain, it is not perhaps likely, that we shall altogether supersede the collective results of the many quite as clever experimenters whose rules (I will not say laws) have been codified for our following. The traditions of earlier time, the records of others' opinions have some worth in them, whatever the acknowledged right of individual judgment. It is not by ignoring the past that the world progresses. But the question here is not of conventionality, but whether, in a line engraving, lines are worth consideration at all.

Let me make one brief remark on the misuse of certain words relating to engraving, "fineness" and "finish." They are anything but synonymous. Fineness, meaning only closeness and littleness of line, indicates no advance in art. The true artist will not employ two lines when one line will serve his purpose as well, or better. Nor will he for any consideration consent to unmeaning lines. It is altogether a mistake to suppose that a work cannot be too fine, fine sometimes meaning finical. There is such a thing as propriety, suitability not only to size but to subject, in the treatment of an engraving. A work may be bold, yet quite fine enough for its purpose. Also it may be finished and refined however bold, in which case to call it coarse simply because the lines may be large and wide apart would be only a misuse of words. Fineness (meaning minuteness), as an artist's word, is not the same as in the proverb, "Fine feathers make fine birds." "Fine" (minute) lines will not make a "fine" (that is a good) engraving. An engraving is fine (meaning good) only so far as art, as distinguished from mechanism, is employed upon it and is visible in the result, visible I would say further to the uneducated if not already vitiated by the words of misleading critics. The art of an engraving is discoverable, even by the uninitiated, in the intention of the lines. You may not have an artist's quickness of perception, nor his mature judgment; but if you see an engraving in which the parts, any of them taken separately, are unintelligible, you will rightly conclude that the engraver did not know what he was doing or how to do it. Do not believe that such a work is a fine work, however close the lines may be together. Art is an intelligent power, designing always. If you can find no proof of that, reject the work as bad.

Every line should be chosen and expressive. When I look at an engraving of a head, and find that the flesh is not distinguishable from the hair; that part of a smooth cheek might be a piece of cloth, engraved in precisely the same line as the cloth in the same engraving (an engraving large enough to admit varieties of texture); when I find face and hair, and what should be aërial background, all of the same substance; when I find an eye formless, a nose of wood or plaster, shapes and contours everywhere undefined and confused, I can but say—despite the admiration of my friend the art critic, and my own general acknowledgment at first sight of much effectiveness, I can but say—"The engraver of this has not learned to engrave, or having learned, has been disloyal to his art; I must condemn the engraving."

Or when I see a landscape, very excellent in light and shadow, in effect, and in tone, or, even more, most carefully preservative of the very brush marks of the original painting; but in which also the sky is as woolly as a sheep's back, and the sheep cut with the same line as the water, and the water with the same line as the grass; what must be my judgment of this as an engraving? An engraving in wood is always a picture represented by lines. Shall I call a picture represented by inappropriate, uncertain, inexpressive lines a fine engraving? The lines are very close together. If there is no beauty in them even only as lines, shall I call that ugly engraving beautiful? As an engraver, I can only condemn it for inefficiency.

Granted that to know a good engraving from a bad one requires some education, some few hints may be of service. To begin, do not be beguiled by the [first look and appearance of the woodcut before you. Your premature satisfaction may be partly owing to the pleasantness of subject or else to the cunning of the draughtsman who knew how to make a good and effective drawing which not even the engraver could destroy. That nice picture may be very badly engraved. Examine it! Do you find any marks of engraving intelligence? If a landscape, does the engraver appear to have had any notion of the growth of a tree, the formation of a mountain, the roundness and lightness of a cloud? Or is it all one flat unvarying set of monotonous and unmeaning lines, so that the treatment of one part would do just as well for any other part. In this first case you have an artist's work, in the second a mechanic's. Examine a figure subject in the same manner. You will not all at once become a judge of engraving, time and study are both needful. But the one clue to guide you out of the labyrinth of erroneous judgments is the constant recollection of the meaning of expression. Expressive work is artistic, inexpressive work is mechanical. The one is good, the other is bad.

DISCUSSION.

Mr. FAGAN (British Museum) said he was not able to express any opinion on the particular point on which the paper turned, except to say that he agreed with Mr. Linton in his description of what wood-engraving ought to be. He did not see any art at all in those American illustrations which he was sorry to find were being imitated in this country. He was a great admirer of the old styles of engraving, for instance, those engraved after the beautiful designs of Albert Dürer and Hans Burgkmair which were incomparable in charm, not only in line, but in precision of drawing.

Mr. QUARITCH said he understood very little of the technique of wood-engraving, his knowledge being rather historical. The most recent period in his mind, for he hardly knew anything of the New World, was that of Bewick, whose work had lived now for 100 years, and would still be admired for countless generations. At first he was employed on little children's books, which were sold for a penny or two, but now they were worth their weight in silver certainly, and were the admiration of collectors. When he became more accomplished he brought out his "Quadrupeds," in 1789, but that book never attained the popularity of the "Birds," the first volume of which appeared in 1797, and the second in 1804. Into that work he put all his artistic skill, so that even at the present day ornithologists said there had never been birds better designed than by this wood-engraver. Not only was his artistic skill very great, but his technique also was excellent, and even in recent editions the impressions were as good as in the first. His own predilections were in favour of early art, for now-a-days the printer was in such a hurry for the design that the artist was unable to do justice to his own genius, if he had it. The work of the present day corresponded very much with that of the *Nuremberg Chronicle*, which came out in 1493, the cuts being by Wohlgemuth, the master of Albert Dürer; it was a stout folio volume, with nearly 2,000 engravings, and must have been one of the most popular works of the day, large editions being printed in both German and Latin. This chronicle was produced for the same purpose as much of our own modern work, simply to amuse the people, but while the former would last for thousands of years, modern art would find its way to the waste-paper dealer.

Mr. W. BISCOMBE GARDNER said he quite endorsed everything Mr. Linton had said.

Mr. FORBES ROBERTSON said it was a great satisfaction to listen to one who was the living authority on his art, and who in his own work showed that he inherited all the best traditions of Bewick, the father of wood-engraving. He went with him entirely in his enthusiasm for the beauty of line, when the line was the creation of a master. He did well to mark the change introduced by Thompson when he adopted the black, instead of the white line, a change which was apt to escape notice. He should have liked Mr. Linton to have gone from the period of Bewick and his immmediate disciples to note the change that had come over not only the practice of wood-engraving, but the tastes of the people. Line engraving in England, not only on wood but on copper, was, perhaps, the finest in Europe. Why was line engraving so much admired? Because you could go back to it again and again; because the line was full of thought and intention. And why had the other style come in? Because, as Mr. Quaritch had said, people had not time to wait for other. He was as great an admirer of line as anyone, and was proud of his collection of Sharp, Strange, and other engravers; but the new style, the mixed style, came in fifty or sixty years ago, when Robinson, Doo, and others began to use line only in parts. At the International Exhibition in Black and White, in Vienna, a few years ago, he was much struck with the picturesque look of this new school, which had chiefly arisen in America, though it was taken there by foreigners, and he thought Mr. Linton had rather underrated that mixed style. It commended itself to the eye at once by this quality of picturesqueness. They went in for values, tone, light, and shade, immediate effects, as was done by the French school, in contradistinction to the more painful stippling and line work to be seen at the schools of the Royal Academy. It was the drift of the age, and it commended itself to a far larger *clièntele* than the other, because it addressed the eye at once, whilst line required time, not only to do it but to appreciate it. He was glad to hear Mr. Linton say that there were some of these engravings which were pleasant to look at, but as far as art, *per se*, went, every word he had said was pure artistic gospel. Nothing could exceed beauty of line, and when it came to the expression of the softer tissues of the human form, some of the works of Sharp and Strange were, to the man who had an eye to see, a joy for ever.

Mr. STANNUS expressed the pleasure with which they had listened to Mr. Linton, whom they all looked up to as the patriarch of the art. The white line might be called the negative effect and the black line the positive; and it would be seen that the positive was the first system employed. The old wood-engravings referred to by Mr. Quaritch were all positive; and so were steel and copper engravings, the effect being obtained by black line, though on these latter there were often little stipples between. There was also another kind of engraving which obtained about 30 or 40 years ago, practised by Roffe, in which the effect was obtained not by line but by dot. There were thus two positive forms—the positive line and the positive dot, and also two negative forms, the white line introduced by Bewick, and of late years the negative form of the dot, little white dots being chipped out, of which Timothy Cole's work was an example. Line was exceptionally admirable for showing form; a shadow cast by a straight edge against a moulding would give the shape of the moulding, and a limb might be so perfectly indicated that a sculptor might model from it. He was much interested in what was said about texture, which could best be shown by line unquestionably, by the direction, thickness, and quality of the line, whether smooth and sweeping, or a cramped and scrabby line, but he would not like to say that line was the only means; but Mr. Linton had said nothing about line as regards colour, and it was in this direction that the new engravers had developed. Colour was equally an art effect, and one to which more attention was paid than formerly. We no longer had the almost colourless pictures of Fuseli, West, and Opie, but the full-blooded pictures of the present day, and line engraving was scarcely adapted in all cases to give this quality. He was in hopes Mr. Linton would have brought some examples of wood-engraving, and he believed that most of the audience were equally expecting to see the two schools, the old and the new, contrasted; and were equally disappointed as himself. He hoped that Mr. Linton would favour them with an exhibition of his work on some future occasion; and he begged to move a hearty vote of thanks to Mr. Linton, whom he hoped would long be spared to enrich English art by his productions.

Mr. H. TRUEMAN WOOD thought the recent school of wood-engraving in great measure owed its faults and merits alike to photography and the public taste as influenced by photography. In that very room he had heard a lecturer on photography holding up an excellent old woodcut and a modern one by the side of it, point out that by means of photography the public taste had been educated to look for something better than they were satisfied with twenty years ago. The public had got to look for minute detail, and the exquisite rendering of tone and colour effect which they found in photography, and hence were not satisfied with the semi-conventionalised older forms of wood-engraving; but this public taste for photography had somewhat avenged itself, for the recent school had succeeded mainly in copying the faults of photography, so that many of their engravings looked like badly exposed photographs. It seemed to be much easier to copy photographic faults, flatness, and absence of vigour, than to render that microscopic minuteness of detail, which was in part one of the beauties and in part one of the greatest defects of photography. On the other hand some of the more recent school of photographers—the impressionist or naturalistic school as they were called—tended to imitate inferior wood engraving, to strive after effects which photography was not capable of rendering, whilst dispensing with those which it would render most satisfactorily. Possibly by means of photographic methods they might get back again to a more vigorous style of work. The modern periodical press, which now depended for its illustrations to a large extent on photographic methods, demanded a rapidity which was incompatible with the finer quality of work, and consequently a bolder and more vigorous style of work was inevitable, and a tendency in this direction could already be traced in periodical illustrations. He should like to know if much of the very fine work in the modern style was not first drawn on a larger scale and then reproduced on a small scale by means of photography, so that the fineness was to a great extent artificial.

Mr. G. BERNARD SHAW wished to say a word on behalf of art critics, who had been rather roughly handled in the paper. In the first place the notices in the Press, which approved of these engravings in *Harper* and the rest, were not contributed by art critics at all, but by reviewers. Still he admitted that the art critic was often more favourable to this style of engraving than Mr. Linton thought he ought to be. Art critics were much more in communication with artists than with engravers; and the one thing above all which an artist resented was that knowledge on the part of the engraver of which Mr. Linton had so well spoken; for to the artist a great deal of that knowledge was altogether intolerable. The worst possible landscape painter was the man who knew that a tree was green, because, as a matter of fact, for artistic purposes a tree was very seldom green. A painter of the impressionist school put into his picture a number of conditions which you saw in nature which used not to be put in pictures at all except by the men of genius. Suppose an impressionist made a drawing in black and white of a scene such as you might often see in England, say a bit of rising ground on a Surrey common on a grey day, with a couple of figures just coming into sight over the brow of the rise. He would draw what he saw, not what he knew to be there; he might know that the man had two buttons on the back of his coat, but he would not draw them because he could not see them. But when that drawing went into the hands of an engraver who had this theory of representing what he knew by appropriate lines, he would not produce what the artist had really seen on the brow of the hill, which would be simply a couple of flat dark tones against another lighter tone representing the sky, but he would want to represent the modelling of the figures' arms, and the roundness of the tall hats, and all the rest of it, which he knew were there, and the result was that he produced an entirely false picture, and made the artist furious. In the old schools of engraving there was too much of this knowledge expressed by lines. It seemed to him that the modern school of engraving aimed at representing tone correctly, and what was actually seen; though he quite admitted that in many of these engravings there was a deplorable lack of the forms which were seen, and which ought to be represented by line, but were not. Nothing was much more unlike the surface of the human hand than the side of a block of wood-paving, and yet he had seen in magazine illustrations these two things represented in exactly the same manner. There the knowledge of which Mr. Linton spoke ought to have come in. Still, modern engraving, with all its defects and omissions, was not more offensive than the old-fashioned engraving in which you missed tone and atmosphere. In some of the best work of Mr. Gardner you had the combination of the two. Mr. Linton's thoroughly good and fruitful lecturing work would recall the men who had educated themselves in tone to the work they could do in the way of line. If they would learn this lesson without losing their command of tone, there would be an enormous advance on the old school of engraving.

The CHAIRMAN said he was not an engraver, and could not, therefore, give an expert opinion on the question raised; but he was inclined to agree with the view put forward in the paper. He was at one time a lithographer, and in drawing on stone, the grain on it produced small dots, but even there it was usual to indicate lines by a stroke of the chalk, for the best work. A very good illustration of Mr. Linton's theory might be found in a comparison between line engraving and mezzotint; every one knew how much superior a line engraving was to a mezzotint. He felt that this question of the two different ways of producing an effect had a broader relation to art than to the mere question of this paper. It reminded him about the question of legitimate and illegitimate water-colour, as if there were only one school and one line of art to follow. He was rather inclined to allow of various ways, not only in water-colour, but in oil painting, and in every branch of art. Still in the main he agreed with Mr. Linton as to the value of line in wood engraving. He concluded by putting the vote of thanks, which was carried unanimously.

Mr. W. J. LINTON, in response, said he had unfortunately failed to hear what was said by Mr. Bernard Shaw, but he agreed with what had been said by Mr. Wood about borrowing from photography, and the endeavour to do by woodcuts what was much better done by photography, and also the endeavour to obtain certain effects in a way which had misled engravers very much. The specimens which Mr. Stannus had brought were quite sufficient to prove his case. He would take the one by Timothy Cole, because he knew him personally, and when he first made his onslaught on this new system Mr. Cole called upon him, and said he perfectly agreed with him. Since then, however, he had to some extent changed his methods. The engraving of the "Sower," which Mr. Stannus had brought, would perfectly exemplify every fault he had mentioned in the paper; the hand and foot were badly drawn, there was no form represented, and no perspective. Colour could be given without line, but colour did not represent form, and he was speaking of form and the varieties of form. He could not see the distinction between positive and negative which had been attempted. If he drew an object with white chalk on a black board, or drew the same thing with the same lines in black on a white surface, why should one be called positive and the other negative? He did not object to dots, or anything which might be brought into use, only, if you had lines, was it not as well to consider whether you could not make them beautiful and expressive.

Miscellaneous.

SUGAR IN INDIA.

Papers respecting the sugar production of India have been received from the Secretary of State for India, from which the following particulars have been extracted:—

On the 8th May, 1889, Messrs. J. Travers and Sons, Limited, wrote to the Under Secretary of State for India—

"The average production of India is given as a ton of sugar per acre, and the produce (with the exception of the three modern mills in Madras) is of the most wretched character.

"In the West Indies (which are also backward) sugar growers obtain two tons of sugar per acre, or double the Indian average, and, with modern machinery, properly crystallised sugar can be made direct from the cane juice at a cost on the spot (that is, without carriage) of 8s. to 10s. per cwt.

"It is no doubt the competition of such direct cane sugar from Mauritius which is leading to the closing of refineries in Bengal, if, as we imagine, those refineries work, not from the sugarcane, but from coarse native sugar.

"In all the statistics sent us, Mauritius and similar sugars are described as refined, but this is altogether misleading. There are no refineries in Mauritius, where sugar is remelted, and the produce of the island is simply raw sugar properly made by modern processes.

"It is such sugar that India ought to make, and the Empire, with sufficiently improved cultivation and machinery, might readily supply the world with sugar. Refining is a secondary process, likely to altogether die out, by slow degrees, as cane and beet manufacture becomes more perfect. The disappearance of refining in Bengal, though hard upon individuals, is really a sign that there is progress elsewhere, and progress which no country is better adapted than Bengal to share in.

"That modern sugar can be well made in India is shown by Messrs. Minchin at Aska, Madras, and it is simply absurd that India should have first to export the labour to Mauritius, and then to re-import sugar from that distant island, which could be as well made, and certainly more cheaply, at home. India is generally regarded as the home of the sugar-cane, and with its teeming population, its climate, and (in some districts) its plentiful water and coal supply, it should be a large exporter of fine sugar instead of an importer.

"The manufacture of modern (or, as it is called, vacuum pan) sugar, to be profitable, must be on a large scale, because it involves costly machinery and chemical and mechanical supervision impossible for ryots, who probably do not extract one-third of the sugar that might be extracted from their crops, and make that third in a shape that looks more like manure than sugar, and which appears to fetch in many parts of India as little as 6s. per cwt. on the spot, whereas Mauritius sugar in India must net double that to pay the grower.

"Vacuum pan sugar making is, probably, only possible on a large scale in India through the central factory system, where the raw canes are bought by the mill from the growers. A system similar to this already prevails in indigo and silk mills in Bengal.

"We do not know whether the Government of India would be able to start a few model factories in suitable districts, or whether they must confine their attempts to develop sugar manufacture to the collection of information and figures like those in the returns forwarded to us. In any case, the efforts of the Government in this direction for some years past cannot fail to be of great value."

This letter was sent by the Secretary of State to the Government of India, and in reply to the points there raised, a series of letters were obtained from authorities in India. The Director of the Department of Land Records and Agriculture, North-West Provinces and Oudh, wrote:—

"The suggestions made by Messrs. Travers and Sons is that the Government of India might start a few model factories for the preparation of sugar by modern processes in suitable districts. This appears to be the only point of practical importance in the memorandum. In my opinion the Government would be ill-advised were it to act on the suggestion. I base my opinion on the general ground that private enterprise in India is now sufficiently alert and well organised to undertake the business of sugar-refining on a large scale, and with ample capital if there were a reasonable prospect of success. That sugar-refining companies working on scientific principles, such as the Rosa Company and the Aska Factory, show no signs of multiplying in India is to my mind a clear proof that, under existing commercial conditions, the prospects of successful trade are small. Nor is the explanation why prospects are not encouraging far to seek. European sugar refineries in India have two markets, and two only, open to them. They can manufacture for export to Europe, in which case they have to contend with the bounty-aided sugars of the Continent, and are no more able than the Mauritius factors to make a reasonable profit on their capital in such a market. Or they can manufacture for local consumption in India, endeavouring to supplant sugars refined by native or crude European processes, and sugars imported from the Mauritius. Here they are met with the great difficulty that the mass of the native population regards with dogged suspicion all machine-made sugar, holding it to be impure and contaminated with bones and blood. The market is thus a very small one, and the prices ruling in it are by no means improved by the quantities of similar sugar thrown in despair upon it by Mauritius planters. Assuming that the cost of producing a given amount of crystallised sugar by modern processes is about the same in India and in the Mauritius (and from such information as I have at hand, I do not think a sugar refinery in India could manufacture cheaper than the Mauritius planter), what are probabilities of commercial success? They are bounded, it seems to me, by the actual success attained by the Mauritius planters, and as we are constantly told that sugar in Mauritius does not pay, scientific sugar-refining in India is not a hopeful industry. The Rosa Factory in these provinces depends more on its rum than on its sugar, and I believe this is the case with the few other similar concerns existing in other provinces.

"The memorandum refers in contemptuous terms to the quality of the common sugars consumed by the Indian public. But they have an almost unlimited and active market, which is at present closed to machine-made sugar; and even if superstitious prejudices could be overcome, there would still remain the question of national taste. The compost known as *gur* has a peculiar flavour which is absent from machine-made sugars, and the tastes of a most conservative people will require to be changed before the local markets of India really open to the European sugar manufacturer.

"I admit all that the memorandum says as to the smallness of the yield of sugar per acre in India, as to the inferiority of the processes employed to extract the juice and make it into sugar, and as to the low quality of the so-called 'refined sugars' of India. But it is conceivable that these rude processes and this small outturn may yield a profit, while scientific processes and high cultivation result in a loss. Not only does the Mauritius system require a large initial capital expenditure, and a large annual outlay, but it also requires a highly paid supervising and controlling agency. I do not defend the imperfections of the Indian system, but I think it is economically explicable.

"There would be some difficulty in introducing the Mauritius system bodily into India, since a prominent feature of that system is that planting and manufacturing are concentrated in the same hands. But as the memorandum points out, a sugar refinery might easily work in an Indian sugar-growing district on the line familiar to indigo planters. It would buy cane at the proper season from cultivators of the neighbourhood, and would restrict its interest in the actual production of the crop advances to growers. A large sugar refinery, I may point out, would have to face two problems which are not easy to solve. The first is the question of carriage. Cane soon dries when cut, and cannot be carried long distances. A sugar refinery has thus to depend for its raw material on a small area devoted almost exclusively to the production of sugar, and this is opposed to the habits and traditions of the Indian agriculturist. The second difficulty is that the machinery of the factory would stand idle for a great part of the year, and occupation would not be forthcoming for the hands, unless a subsidiary business, such as the manufacture of rum, is added to that of sugar refining. The market for rum in India is not large, and is probably sufficiently supplied by existing concerns."

Mr. M. Finucane, Director, Department of Land Records and Agriculture, Bengal, wrote:—

"As regards the question of improvements in manufacture suggested by Messrs. Travers and Sons, I would remark that it seems not unreasonable to suppose that such improvement is possible, and it is not improbable that the establishment of model factories in suitable districts, whether by Government or by private individuals, encouraged or subsidised by Government, would yield beneficial results. Messrs. Mylne and Thomson, in their letter, dated 28th February, 1880, to the address of the Collector of Shahabad, reported that they had for years been trying whether cane could be profitably purchased and worked off at a central factory, and the conclusion to which they came was, that the price demanded for cane by the growers, which price the growers realised by making it into *goor*, was so high, that the experiment was not deemed to be profitable and was discontinued. Messrs. Mylne and Thomson added that the Rosa Sugar Works at Shahjehanpore had not found it advisable to make arrangements for crushing cane and making refined sugar from the juice direct, and the inference would seem to be that central factories, such as are suggested by Messrs. Travers and Sons, will not pay. The reason given for this is, that the factory could not work at a profit, if it paid as high prices for the cane as the cultivators realise by making it into *goor*. But this is only stating the fact in another shape, and is no explanation of the problem—why is it that with cheap labour, cheap raw material, refined sugar cannot be manufactured in India at a lower price than that for which it can be imported from the Mauritius or England? A similar question may be asked as regards other products, for example iron—why is it that with cheap labour and cheap iron ore at Ranigunge, it is found profitable to import manufactured iron articles from England? I am not at present in a position to furnish an answer."

The letter from the Government of India to the Secretary of State, covering the correspondence, is dated "Calcutta, 24th December, 1889," and is as follows:—

"The improvement of sugar production and manufacture in this country has been the subject of attention both of the authorities and of capitalists since the beginning of the century, and various attempts have been made to establish factories, none of which appear to have been attended with any permanent success unless supplemented by the sale of rum and liquors. Sugar refining alone has not proved sufficiently profitable to maintain a factory. If this had been the case, there appears to be no reason why the industry should not have been largely taken up by private capitalists.

"Some of the main difficulties against which the industry has to contend are believed to be these:—

"(*a*) The cultivation of sugarcane is limited by the supply not only of water for irrigation, but also of manure.

"(*b*) As cultivation in India is confined to small farms or holdings, each cultivator who is able to grow the crop at all can only find manure enough for a small area, generally less than half an acre, of sugarcane. The plots of sugarcane are therefore greatly scattered, even in a canal-irrigated tract.

"(*c*) A central factory has accordingly to bring in its supplies of cane in small quantities over varying distances, in many cases the distance being great.

"(*d*) The carriage of canes over a long distance, even in a climate like that of the Mauritius, is detrimental to the juice for purposes of sugar making. It is much more so in India, where the canes ripen at the season when the atmosphere is driest and suffer, therefore, the maximum of injury.

"(*e*) The Mauritius system of growing large canes at intervals is not adapted to the greater part of India where, in order to prevent the ingress of dry air into the fields, small canes have to be grown in close contact.

"(*f*) The amount of cane which can be grown, limited as it is by the supply of water and manure, barely suffices for the wants of the Indian population. It seems to be at present as profitable to produce coarse sugar for their use, as highly refined sugar for export. There is, therefore, no sufficient inducement to capital to embark on the more difficult and expensive system.

"A further obstacle to sugar refining in India exists in the high differential rate which the conditions of our excise system require to be placed upon spirits made on the European method. as compared with that levied on spirits manufactured by the indigenous process. The sugar refiner in India is thus placed at a disadvantage in respect to the utilisation of his molasses in the form of spirits.

"In view of the circumstances above noted, we are unable to advocate any attempt being made at the cost of the State to establish model factories. We are inclined to attach much confidence to the views and conclusions formed by Messrs. Thomson and Mylne, who have paid, for many years, practical attention to the subject of sugar cultivation and manufactnre by ryots, and were the first to introduce the portable sugar-mills which have now spread over India. They advocate the gradual improvement of the ryots' method of manufacture rather than the introduction of more expensive and centralising systems. The Provincial Departments of Agriculture have, of recent years, directed attention to this question, and may usefully be desired to continue to do so.

"We are also willing to advocate the establishment of agricultural experiments in those comparatively limited tracts of the country (such as Eastern Bengal, where there is a moist climate and a more or less abundant supply of manure) in which the Mauritius methods of cultivation have *primâ facie* prospects of success, and we are prepared to advise our Local Governments and Administrations to give every reasonable support to sugar factories and refineries which may be established by private enterprise."

Messrs. Travers's reply to the correspondence is dated 21st February, 1890:—

"We observe that while all the officials who have reported fully confirm our information as to the great, and indeed excessive, waste in Indian sugar manufacture, yet that they are able in some degree to explain the causes of the existing state of things, while the opinion is general that it would not be wise for the Government to establish experimental central sugar factories.

"It would be presumptuous on our part to offer any comments on a question so fully taken up by the local authorities on the initiative of the Secretary of State.

"It only remains for us, in concluding the correspondence, to acknowledge the very great courtesy with which our necessarily imperfectly informed remarks have been received, and the promptitude with which action has been taken owing to the recognition by the India-office and the local authorities of the great importance of sugar manufacture to India, and the possibility of a great development in it.—We are, &c.,

"Pro. J. Travers and Son, Limited.
"(Signed) J. W. Rogers.

"P.S.—We may mention that 'German granulated,' a small white dry crystal sugar made direct from the beetroot, is now being shipped from Hamburg to India; so that the ryots will not have Mauritius only to compete with at home. We believe this sugar costs about 16s. per cwt. laid down in Bombay, and that the bounty on its export does not exceed 6d. to 9d. per cwt."

THE PRODUCTION OF LATAKIA TOBACCO.

The *Journal de la Chambre de Commerce de Constantinople* says that the district of Latakia, which gives its name to the famous tobacco, is situated in the north of Syria, and occupies the site of the ancient Laodicea, in the neighbourhood of Tripoli; but the port, formerly so renowned, has been blocked up with sand, so that only small, lightly-laden vessels can now enter. Behind the town extends a vast plain to the south beyond Jibleh, as far as the range of hills inhabited by the Noçâiris or Ansarieh. This tribe is specially engaged in the cultivation of Latakia tobacco, and obtain considerable profit from it. The Nahr-el-Kebir, which runs through the plain, affords the necessary irrigation. The following is the method adopted in the cultivation of the tobacco:—Towards the end of December the ground is broken up and the sowing takes place in January, ten or twelve seeds being placed in holes from four to five feet in depth. As soon as the sprouts appear above the ground they are covered with mats which are taken off when the sun shines. Women and children are employed to frighten away the birds and see that they commit no injury to the sprouts. In February the plants are transplanted to another field, and earth is plentifully piled up around them, while in March they are kept well watered, and in April the harvest commences. The first leaves are placed to dry in the sun or by the fire; these constitute what is called the new tobacco, and is particularly appreciated by the fellahs themselves as it is considered stronger than that obtained subsequently. From April until the month of August the plants are watered according to the state of the weather, the yellow leaves are lopped off, and the buds are removed in order to strengthen the general growth of the plants. The full harvest takes place in the commencement of August, and, towards the south, in September. The entire plant is cut, the leaves removed, tied up in bundles, and placed in the sun to dry, care being taken to frequently turn them over. In November, the tobacco is sufficiently dry; it is placed in horse-hair sacks, and put upon the market. The merchants, however, subject the leaves to a new drying, and then sort them according to colour, perfume, and general quality. The different varieties placed upon the markets are the *Abou-Richa* or *Djebeli*, which is the finest quality, and is only obtained in the high plantations of the Noçaïris, and which is much in favour in Europe as well as in Egypt. The *Djidar* is a little rougher in quality, but burns well, and is much appreciated by great smokers. The *Schick el Bent* very closely resembles the *Djebeli*, with which it is frequently mixed by the retail dealers. The plain of Koura, which extends from the foot of Lebanon to Nahr-el-Kelb between Tripoli and the mountains, also furnishes excellent Syrian tobacco, the best products being those of the villages of Sebail and Serai. The district of Gabail, and particularly Kesrasan, furnishes the finest variety, and also the most expensive. This tobacco leaves a white ash, while Oriental tobaccos as a rule leave a black or dark grey ash. The southern districts of Lebanon, and particularly the region of Tripoli, only supplies very ordinary varieties of tobacco. In the districts of Aleppo and Damascus, a little tobacco is also grown, but of an inferior quality.

CORRECTION. — The Secretary of the Royal Colonial Institute has written to point out an oversight in the obituary notice of the Duke of Manchester. His Grace was President of the Colonial Institute until 1878, from which time H.R.H. the Prince of Wales has held that office. The Duke of Manchester was Vice-President and Chairman of the Council.

General Notes.

DRAWING SOCIETY.—The first annual Exhibition of the Drawing Society was opened at the Nineteenth Century Galleries, Conduit street, on Monday last. The object of the society, which was the outcome of a paper read by Mr. T. R. Ablett before the Society of Arts in 1888, is to encourage the teaching of drawing among children as a method of education. The Exhibition consists mainly of drawings sent in by school children for the prizes offered by the society. The classes in which these prizes were offered were as follows:—1, Technical; 2, Scientific; 3, Educational; 4, Artistic; 5, Decoration; 6, Miscellaneous. Feeling that the efforts of the society deserved encouragement, the Council offered 12 Society of Arts Bronze Medals to be awarded in these different classes. There is also in the Exhibition a small collection of pictures and sketches done in early childhood by various distinguished artists.

SILK ASSOCIATION.—The Ladies' Committee of the Silk Association of Great Britain and Ireland have made arrangements for the holding of a small Loan Silk Exhibition of goods of British manufacture on the 6th of May next, in Lord Egerton of Tatton's ball-room, at No. 7, St. James's-square, London. The Exhibition will be open for a fortnight. It is hoped that all the various branches of the silk industries of Great Britain and Ireland will be adequately represented both through the manufacturers and distributors. Intending exhibitors are requested to communicate as soon as possible with the President, addressed to Leek, Staffordshire, who will supply conditions and all particulars.

PETROLEUM IN SERVIA.—The Belgian Minister at Belgrade, in his last report to the Belgian Foreign Office, says that up to the present time no petroleum in a liquid state has been discovered, but the country is exceedingly rich in bituminous schist. The following are the principal places in which it is found:—The Department of Pojarevatz by the side of the River Pec, between the villages Zélénik and Lechuitza, stretching towards the villages of Vodkovitch and Kakova Bara, up as far Snégatine; the Department of Kniajevatz, in the whole of the south-west basin of the Timok, from Sorlingue near Kniajevatz. Bituminous schist has also been found in Brehatz and Nina, while in the neighbourhood of Trgovichte there is a veritable mountain of schist. In the Department of Nisch it is found at Zelachnitza, and it is frequently met with in the Departments of Alexinatz and Tchoupria, particularly in the basin of the Montnitza and Vitchevatz which extends to the north as far as the River Ressava, and to the south as far as Rajagne. In the Department of Valievo it is found in the basin extending from Kaloubara to Ligne. Up to the present no one in Servia has engaged in the business of extracting petroleum from these deposits of schist.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

FIFTY YEARS OF GOVERNMENT AID IN SCIENCE AND ART EDUCATION.

By Frank Cundall.

I.—Introduction.

It was in 1835, that the seeds were sown of that Government assistance which is now so widely and so beneficially felt by students of all grades in science and in art. In that year a Select Committee of the House of Commons was appointed "to inquire into the best means of extending a knowledge of the Arts and of the Principles of Design among the people (especially the manufacturing population) of the country."

Two years later, as the result of the Committee's consultation with those best calculated to advise, a Government School of Design was established, under the auspices of the Board of Trade, at Somerset-house, in rooms which had been recently vacated by the Royal Academy. Thus it was intended to supplement by State aid, on a larger scale, the encouragement which the Society of Arts had, by premiums and other means, been giving to arts, manufactures, and industries for the previous eighty years.

As the formation of such a school was, in a measure, experimental and without the precedent of any similar institutions in this country, William Dyce, R.A., who had published a pamphlet on "Schools of Design as a part of State Education," was commissioned, in 1839, to inspect and report upon the Government drawing schools on the Continent, of which no less than eighty existed in France.

In addition to the ordinary classes for drawing and design, lectures were given and classes were formed for female students.

It was felt that in order to train students successfully, it was necessary to surround them with examples of the best works of industrial and decorative art of all countries and all time, such as Paris already possessed in the galleries of the Louvre. So far as the funds at command permitted, collections of casts of antique sculpture, and of architectural details of divers styles, as well as prints and actual objects of ornamental manufacture were gathered together. These were supplemented by donations, of which a cast of Ghiberti's famous gates was by no means the least important. As a means of improving the art knowledge of weavers in England, a loom and a Jacquard machine were set up at Somerset-house, and instruction was given in weaving and the application of design to fabrics. But the class was never numerously attended, and the course of instruction was superseded by that given in the Branch School of Design at Spitalfields, which was established in 1841, with the special object of educating the weavers of the neighbourhood in the matter of taste and skill.

It was early decided to extend the usefulness of the Central School, by making grants towards the formation and encouragement of schools in the manufacturing districts. Amongst the earliest formed were those of Manchester, York, Coventry, Sheffield, Nottingham, Newcastle, Norwich, Glasgow, and Birmingham. At the last-named place there had been a Society of Arts in operation since 1821, and the Newcastle school was assisted by the North of England Society for the Promotion of Fine Arts. Of these schools, the first to make rapid advances were Manchester, Birmingham, and Glasgow.

As the Council found it no easy matter to obtain persons qualified to give instruction at Somerset-house, they determined to anticipate this difficulty with respect to local schools, and train students with a view to their becoming instructors; and some of the most successful were sent, at the Council's expense, to further prosecute their studies on the Continent, thus doing for ornamental art what the travelling studentships of the Royal Academy do for the fine arts. One of the first exhibitioners was sent as master to the school at York; and thus was foreshadowed the valuable work in the training of art masters which has since been accomplished at South Kensington. Another of the original exhibitioners became master of the Spitalfields school, and afterwards at Manchester, and is now an officer of the South Kensington Museum. A series of drawing-books of ornament and design was issued, and a lending library of art books was formed for the use of the students. With regard to the assistance to be granted to local schools, it was found that it was far more useful to lend, for a short time to the schools in succession, a good collection of examples, rather than divide the objects at disposal amongst the several schools, and thus minimise their value; the plan of circulation which was then adopted has since been carried out with great success.

The principal classes at Somerset-house, and indeed in the various local schools—of which there were seventeen in 1851—consisted of actual designers who attended for the further study of ornament, of persons practically engaged in mechanical pursuits desirous of a better acquaintance with the arts of design, and of younger men who studied with a view to becoming designers for manufacturers and decorators. The female students chiefly devoted their time to designing patterns, drawing on wood, and painting on porcelain. In addition to the art masterships which several of the students acquired, some obtained situations with manufacturers who began to show an appreciation of the instruction imparted, though others, less liberal in spirit, said that "those designs were best that sold best;" and one man carried this principle so far as to turn upside down the designs of his popular teapots, in order to get new dies without trouble or cost. But, owing in part to a division of personal responsibility, and in part probably to an unreadiness on the part of the manufacturers of England to learn how to improve their wares by a cultivation of the arts, the results of the administration were not so successful as had been anticipated, and although the disparagement cast upon the School of Design by some of its opponents was too severe, a reorganisation was decided on.

The nature of the work to be done was first thoroughly grasped at the time of the Exhibition of 1851, when a great and varied experience was gained with respect to the comparative merits of the art industries of this country and those on the Continent. And in order to fully comprehend the history of the subject, it will be necessary to consider for a few moments the causes and effects of the Great Exhibition.

Although art in England was then as high as that of foreign countries, and her manufactures were second to none in excellence of workmanship, yet there was a lack of that unison and harmony between art and industry which had been understood on the Continent from the time when Ghirlandajo and Verrocchio chased goblets, and Holbein designed jewellery and painted table-tops, and which had not been unknown in this country in the Middle Ages, when workers in metal and embroiderers were employed in the service of the Church for the great monasteries and cathedrals, and vestments wrought in England were highly prized throughout Europe. But with a reformed faith few of such works of art were required.

In 1845, the Council of the Society of Arts, recognising the need of a better application of art to industry, offered, amongst their many endeavours in this direction, prizes for the production of a tea-service and beer jugs. The prize for the former was won by Mr. (afterwards Sir) Henry Cole, with a set executed by Mintons after his own design. He tells us in his reminiscences of "Fifty Years of Public Work" that "the Society's annual art manufactures exhibitions were started by these tea cups and beer jugs, and expanded by the Prince into the Great Exhibition of the Works of Industry of all Nations in 1851."

> "Think nought a trifle, though it small appear,
> Small sands the mountain, moments make the year."

In 1848, the success which had attended this series of industrial exhibitions held by the Society of Arts, revived the proposals to have a national exhibition of British arts and manufactures, which had hitherto had no practical result.

In June, 1849, the Prince Consort, as President of the Society of Arts, began to take a deep interest in the scheme, and a series of events followed which led to the development of the undertaking into the first Great International Exhibition ever held (although the idea of internationality had been previously mooted in France by M. Buffet, the then Minister of Agriculture and Commerce, in connection with the exhibition held in Paris in 1849). In the following year the Society of Arts held, under the active presidency of the Prince, an Exhibition of "Antient and Mediæval Art," which included many objects of the greatest artistic and historic interest, and which proved a fitting prelude to its successor of 1851. The site originally granted for the Exhibition by the Office of Works—the quadrangle of Somerset-house—had of necessity to be abandoned; and after a fierce opposition from certain of the residents in the neighbourhood, the press, and a portion of the House of Commons, a suitable situation was secured in Hyde-park, and the well-known Palace of Glass, designed by Mr. (afterwards Sir) Joseph Paxton, was there erected.

Any record of the labours of the Prince Consort and the Royal Commission in the organisation and carrying out of this great undertaking would be out of place here; but it may fairly be said that it was in no small measure owing to the knowledge, foresight, and unceasing industry with which Mr. Cole—aided by Mr. Digby Wyatt, Mr. Owen Jones, and other artists—seconded the initiation and influence of the Prince Consort, that the Exhibition had such important educational results, and had, for better or worse, a far-reaching effect upon the trades and industries of this country. Whether the manufacturers of England did not then teach foreigners more than they learned of them is a moot point, but it is undoubted that they recognised their inferiority to the best of continental nations in the application of art to the purposes of manufacture. Subsequent comparisons have shown that the lesson was not learnt in vain.

About this time it was found necessary, as already stated, to reorganise the Government School of Design, and the general superintendence was placed in the hands of Mr. Cole, at whose suggestion its title was changed to the "Department of Practical Art." A selection of objects were purchased from the Exhibition with a special Government grant of £5,000; and, supplemented by articles from the museum of the old School of Design and some valuable china and lace lent by the Queen, these were opened for public exhibition at Marlborough-house (now the residence of the Prince of Wales) in 1853. A small portion of this, the prototype of the South Kensington Museum, was devoted to the exhibition, in a "Chamber of Horrors," of things to be avoided as opposed to the canons of art, but after a few years' experience this demonstration of "false principles" was withdrawn, in deference to the outcry raised by the makers of the "horrors" against this official pillory.*

In 1853, a science division was added to the Department of Practical Art, and it became what it now is—the Department of Science and Art. Three years later it ceased to be connected with the Board of Trade, and, being allied to the Educational Establishment, became subservient to the Lord President of the Council and the Vice-President of the Committee of Council on Education. And under this *régime* it has remained up to the present time.

The history of the Department from 1857, in which year it was removed to its present home at South Kensington, may be most conveniently considered by taking separately its two great divisions, which, with the museum common to both, form the complete organisation of State-aided education in science and art. Though based on similar lines, and in many things identical, and ruled by one permanent head, the Secretary to the Department, each of the three sections has its own director, and its own sphere of action.

II.—SCIENCE DIVISION.

Training Schools.—When the Science Division was added, it was decided to follow the example of the Art Section, and, in addition, to founding a training school in the metropolis, to render assistance to local scientific institutions in the provinces; and at the same time the Government School of Mines, the Museum of Practical Geology, and the Museum of Irish Industry were all amalgamated with the Department. But the provincial schools did not flourish; and it was not until 1860 that aid was systematically given throughout the country.

The subjects of instruction embraced geometry, mechanical and machine drawing, physics, chemistry, mineralogy, geology, and natural history; and to these have, from time to time, been added various allied subjects, including sound, light, heat, magnetism, electricity, navigation, nautical astronomy, steam, biology, building construction, physiography, agriculture, hygiene, &c.

The teachers had to obtain, by passing an examination, a certificate of efficiency; and the Department made grants on those pupils who, after having received a certain number of lessons from a certificated master, passed the examinations, with additions for prize winners. Scholarships, medals and prizes, and contributions towards the purchase of apparatus, and, since 1865, towards the erection of buildings, are given; and apparatus and models are also lent to the schools. Thus skill and application are encouraged in pupils and teachers alike; and, in order to see how fully this encouragement has been appreciated, it is only necessary to note the large increase which has taken place in the number of students.

In 1861, there were established 31 science schools with 1,330 pupils under certificated teachers; and in 1889, these had grown to 2,195 schools, with 126,387 pupils; and in 1888 no less than £95,228 was paid in State aid to teachers, for prizes, and for aid towards the cost of examples and fittings. By the Technical Instruction Act of 1889, local authorities are empowered to levy a rate not exceeding a penny in the pound to supply, or aid the supply of, technical or manual instruction.

Whitworth Scholarships.—In 1865, Mr. (afterwards Sir) Joseph Whitworth founded scholarships, to the value of £3,000 a year, for the promotion of the mechanical industry of England, and vested them in the head of the Education Department. The terms under which these scholarships are awarded have varied considerably. They now consist of 12 scholarships (four of which are awarded each year) of £125, tenable for three years, and thirty prizes, some of £100 each and the rest of £50. Candidates—who have to be twenty-six years of age, and must have been engaged in the workshop of a mechanical engineer for at least three years—are examined in theoretical subjects. Up till May, 1889, no less than 344 scholars have, by the munificence of Sir Joseph Whitworth, received practical encouragement in the pursuit of their profession. They have come from all parts of the United Kingdom, and number in their ranks the name of more than one who has since risen high in the engineering world.

Exhibitions and Scholarships.—Other prizes for the science student are given annually in the shape of seven Royal Exhibitions of the value of £50 a year for three years—tenable, four at the Normal School of Science and Royal School of Mines, and three at the Royal College of Science, Dublin; twelve national scholarships open only to students of the industrial class,* entitling the holders to free education at any of the above-named institutions, with maintenance allowance during the sessions; and six free studentships at the Normal School of Science, in addition to local exhibitions which are contributed half by the Governmeut and half by the locality benefiting.

Royal School of Mines.—The Royal School of Mines, intended for instruction not merely in mining but in all the branches of science which have a direct bearing upon the development of the mineral and agricultural resources of the country, was established in Jermyn-street in 1851. It has had a somewhat chequered career. There was always in connection with it a Museum of Practical Geology (which still remains in Jermyn-street), and in 1853, the Royal College of Chemistry, which had started in Oxford-street in 1845, was added to it. In

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* In 1884, a similar principle was employed with good educational effect at the Health Exhibition by the comparative illustration of sanitary and insanitary dwellings, and healthy and unhealthy clothing.

* By industrial class, the Department understands those whose incomes do not exceed £200 a year, and their children.

1872, owing mainly to the want of proper accommodation in Jermyn-street, the courses of instruction in physics, chemistry, and natural history were removed to the Science Schools erected in the Exhibition-road, adjacent to the South Kensington Museum. Later on, the course of instruction in geology, and the metallurgical department followed. This migration westward, and the consequent greater facilities for practical instruction, caused a considerable increase in the number of pupils; and so much has this increase developed that, large as the Science Schools are, they have proved inadequate for the present needs of the professors; and many classes have now perforce to be held in temporary buildings on the other side of the Exhibition-road.

Instruction to Teachers.—As an incentive to teachers in science to become more proficient, instruction is yearly given to about sixty, free of cost to themselves, at the Science Schools; their travelling expenses and maintenance are defrayed for them, and, in addition, short courses of instruction of about three weeks' duration are given in the summer months to some two hundred teachers, who take advantage of their holidays to improve themselves in their profession. Thus, the Normal School of Science and Royal School of Mines, as it is now called, imparts instruction to teachers and students of the industrial classes, selected by competition in the examinations held by the Department. Other students are, however, admitted on payment of certain fees; and lectures are given in the evenings to working men. Besides the scholarships and exhibitions already referred to, various medals and prizes, founded by private liberality, are granted; and students can, by undergoing certain courses of instruction, and passing certain examinations, obtain the Associateship of either the Normal School of Science or the Royal School of Mines.

Science Collections.—When the Science Section was added to the Department of Practical Art, it was fully intended that there should be a science as well as an art museum. On the removal of the Department to South Kensington, the science collections — comprising foods, animal products, models of machinery, examples of structure and educational apparatus—were arranged for exhibition. In 1874, a Royal Commission on scientific instruction recommended the formation of a collection of physical and mechanical instruments, and the amalgamation, under a Minister of State, of such a collection with the existing science objects and the museum of patented inventions, with its series of models illustrative of the history of the steam-engine from the earliest times. And in 1876, on the occasion of an international loan collection of scientific instruments and apparatus held at South Kensington, which was most numerously attended, the desirability of forming a National Scientific Educational Museum was much dwelt upon, but it was not until 1883 that the Patent Museum, which had found a home at South Kensington at the same time as the Museum itself, came under the jurisdiction of the Department. The old iron building by the entrance to the Museum was vacated in 1886, and the collections are now placed in galleries to the south of the late Horticultural Gardens.

The various committees which have from time to time considered and reported on the science collections have been almost unanimous in the opinion that it was desirable to maintain and further develop the present collections, which are found to be not only of interest to intelligent visitors, but also of great educational importance for use in the science schools. And a special committee, appointed by the Treasury to consider whether certain obsolete objects in the science collections could not be dispensed with in order to make room for more important contributions, reported, as late as July, 1889, that "little, if any, space can be gained by weeding the existing collections, and that . . . . an exhibition space of about 90,000 square feet should be provided without delay, and would suffice for the requirements of a creditable Science Museum."

The power vested in the Department by the Patents, Designs, and Trades Marks Act, to demand from any inventor a model of his invention on payment of the cost of production, is of very great importance, and must of necessity facilitate the augmentation of the collections with respect to future inventions, and the ultimate formation of a scientific educational museum worthy of the nation.

Educational Library.—Allied to these collections is the Science and Educational Library and Reading-room, placed in the Museum, where students can refer to many thousands of books relating to science in all its branches.

Buckland Museum.—Before leaving this branch of our subject, we must briefly refer to one or two other features of the Science Division. In 1864, the late Mr. Frank Buckland commenced at South Kensington, under the auspices of the Department, his experiments in fish hatching; and he gradually created a small museum of fish culture, which was increased by donations and purchases; but since the death of its promoter in 1880, the museum has not made any perceptible advance, and, indeed, the committee mentioned above reported that there was no necessity for its retention.

School of Naval Architecture.—In 1864, a Royal School of Naval Architecture and Marine Engineering was, at the request of the Lords of the Admiralty, opened at South Kensington, where students received a course of instruction, supplemented—for those who were British subjects—by practical work in the Royal dockyards and factories. But, in 1873, the school was transferred to the Royal Naval College, at Greenwich, which was considered a more fitting home for it.

Geological Survey.—In recording the work of an important scientific character, executed under the direction of the Department, the geological survey of the United Kingdom must not be omitted. The one-inch map comprising the solid geology of England and Wales was completed in 1883, and good progress is now being made with those of Scotland and Ireland.

Museums at Edinburgh and Dublin.—Closely allied to, and under the supervision of the Department, are the Science and Art Museum at Edinburgh; and at Dublin, the Science and Art Museum, the Royal College of Science, the Royal Hibernian Academy, the Royal Botanic Gardens, and the Royal Zoological Society.

The Edinburgh Museum, established in 1812, in connection with the university of that city, but subsidised by Government, originally contained examples of zoology, mineralogy, and geology. In 1855, it was transferred to the Department, but with the reservation of certain rights to the University, and in 1866 the new museum was opened to the public. An Art Section has since been added and forms a not inconsiderable feature of the institution.

In emulation of the London Museum of Practical Geology, a Museum of Irish Industry and Government School of Science Applied to Mining and the Arts, was created in Dublin about 1852. This, while it still remained allied to the Royal Dublin Society, to whom it owed its promotion, was, in 1853, placed under the direction of the Department of Science and Art. After various Government committees had considered and reported on the subject, it was decided, in 1865, to sever this institution from the Royal Dublin Society, and reconstitute it as a Science and Art Museum. In 1868, the Government resolved to create a separate Department of Science and Art for Ireland, and a Commission was appointed, with the Marquis of Kildare (now Duke of Leinster) as chairman, to report upon the best means of carrying out the scheme. The Commission, after giving to the subject the closest attention, reported strongly against the proposal, pointing out, *inter alia*, that it "Would involve the severance of the science and art schools of that country from those of England and Scotland; and would thereby deprive the students of the Irish schools of the great advantage of Imperial competition, and so tend to restrict their prospects to the comparatively narrow field afforded by their own country, which would undoubtedly be a disadvantage."

From the foregoing brief review, it will be noted that the influence of the Department with respect to education in Science is both thorough and widespread; many thousands of students are being fitted yearly to fill posts requiring sound scientific training.

III.—Art Division.

It is now necessary to consider the Art Section of the Department. When the Schools of Design were reorganised in 1852, the objects of the new Department were declared to be the promotion of elementary instruction in drawing and modelling with special reference to ornamental art, and the practical application of such knowledge to the improvement of manufactures.

Art Teachers.—With these objects in view, the training school for teachers was reconstituted; special classes for instruction in all branches of practical art were opened; examples for drawing were offered to elementary schools at half cost price. Art in the provinces was freely encouraged. Existing schools were affiliated to the Department, and inducement was given for the formation of new schools and classes; and the system of aid which we have seen applied to the science schools was likewise practised in this case. To teachers was given, in 1856, a direct interest in the success of their pupils, by the scheme which is known as payment by results; and though this system has since been modified by a partial substitution of capitation fees, a teacher's income is still influenced by the success of his own pupils.

Scholarships.—In the same year, local and national scholarships,* the latter, fifteen in number, tenable only at South Kensington, were established. Gold medals and other prizes are also awarded at the same time.

Schools of Art.—The aid granted to schools of art briefly comprises—payments on the results of examination of works executed during the year, medals and prizes, scholarships and studentships, grants for buildings and the purchase of examples and apparatus, and loans of works of art and books. The sum expended by the Department on these objects during the year 1887–88 was £90,996.

The number of students in the School of Design and branch institutions before their re-organization in 1852, was 6,947. These had in 1857 risen to 12,509 in local schools, and 396 at South Kensington. In 1888, there were, irrespective of some 806,000 receiving elementary instruction in drawing in elementary schools, 84,000 pupils receiving State-aided education in art, in schools of art, art classes, training colleges, &c.

Training School.—The training school, established originally at Somerset-house, was removed to Marlborough-house in 1853, and four years later was taken to South Kensington. Upwards of 24,000 pupils have received instruction within its walls during the last thirty-two years. Instruction is given in freehand, architectural and mechanical drawing, practical geometry and perspective, painting in oil, tempera, and water-colours, etching, modelling, moulding and casting. The school is mainly intended for the advanced instruction of those who have shown their ability by gaining scholarships and who intend to become art teachers; but schoolmasters and mistresses, and pupil-teachers and artisans can attend evening classes at low rates of admission; and the courses of instruction are also open to the public on payment of higher fees. In 1871, however, it was found necessary to impose an entrance examination on these fee-paying students in order that the instruction given in the schools should not be diverted from its proper channel, and the schools become an academy of the fine arts.

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* As early as 1851 a competition took place, and 9,903 works were sent up by the metropolitan and local schools of art. Of these, 2,641 were exhibited at Marlborough-house, and subsequently a selection of about 60 were shown at the Great Exhibition, and obtained favourable notice from the sub-committee appointed to adjudicate upon the designs for manufactures.

Amongst the lists of the national scholars, gold medallists, and certificated teachers, may be seen the name of many an artist who has strayed from the bounds of decorative art to win for himself fame in the fields of painting as a fine art. On the other hand, the schools have been the means of training—in addition to those who have become art-masters, and have in their turn imparted instruction to a younger generation—a very large number of designers for all kinds of manufactures, and who have succeeded in a great measure in driving out the foreign element which pervaded the designing section of British factories. In Manchester, Birmingham, Glasgow, Sheffield, Nottingham, Hanley, Macclesfield, and elsewhere, students of the schools of art are doing excellent work, and they are also to be found in France, Russia, Spain, America, and the British Colonies, putting to good account the instruction imparted to them at South Kensington. The importance of the work carried out by the Department, with a view to the improvement of design, is now recognised, and manufacturers encourage their workpeople to avail themselves of the local schools of art, and in some cases they have compelled their apprentices to attend the art-classes by a clause in the indentures.

Work in the Colonies.—In 1887, the Department undertook — upon application from the Colonial Government, or Education Department, or other public body in any colony—to arrange for the examination of their schools in science and art; on the results of which examinations, certificates and results of awards are issued, the entire cost being defrayed by the local authorities. In 1888, works were examined from Jersey, Guernsey, the Isle of Man, Adelaide, Melbourne, Sydney, Wellington, Pietermaritzburg, and Port Elizabeth.

Workshops.—In organising the Museum, one of the first objects to which attention was paid was the establishment of architectural and decorative workshops, where, in addition to the constructive work executed, the students, under the supervision of Mr. Godfrey Sykes, and other competent masters, designed much useful decorative ornament, such as the terra cotta, glazed earthenware, sgraffito, and mosaic decoration in the Museum itself, as well as the colonnade round the top of the Science Schools, the arcades flanking the Horticultural Gardens, and the frieze round the top of the Royal Albert-hall. But about 1870, when the charge of the Museum buildings and their erection was transferred to the Office of Works, the work ceased.

IV.—South Kensington Museum.

The magnificent collections which now fill the courts and galleries of the South Kensington Museum had, as has been stated, their origin in the objects acquired by the old School of Design, which, supplemented by purchases and gifts from the 1851 Exhibition, and loans by the Queen, were opened to the public at Marlborough-house in 1852. It was at the same time decided to obtain a yearly grant from Parliament for the formation of a collection illustrative of the application to industry of the fine arts of all countries and periods. Thus England, which a few years before had found herself immensely behind other nations of Europe in this respect, set an example to them, which France, for one, was not long in following, in the formation of an Industrial Art Museum of the utmost value to students of design. It was a revival in the 19th century of that spirit which in the 15th century induced the Medici to supply in their gardens—to the manifest advantage of many a rising Florentine artist—objects worthy of study and imitation.

The year 1856 marks an important epoch in the history of the Museum, for it was then transferred from the Board of Trade to the recently-created Department of Science and Art, and was shortly afterwards removed from Marlborough-house to a temporary iron building on land at South Kensington, which the Commissioners of the 1851 Exhibition, aided for the time by a Government grant, had purchased out of their surplus funds for the furtherance of institutions devoted to science and art.

Objects in the Museum.—To enumerate a tithe of the important collections of objects acquired by the authorities would occupy far more space than is available in this notice. It is estimated that, if sold at the time of their acquisition by the Museum, the objects presented and bequeathed would have realised upwards of a million sterling, while the Department itself has only been able to purchase, from 1856 to 1889, objects for the Museum and for circulation, and books for the libraries, to the extent of a little more than £420,000.

Purchases and Bequests.—Mention must however be made of a few of the more important, such as the Bandinel and Bernal collections of pottery and porcelain; of the Soulages collection of Italian ornamental art from Toulouse, which would never have been secured for the nation but for the public spirited action of the Prince Consort and Mr. Cole; of the Gigli-Campana collection of Italian sculpture, and the Soltikoff collection; of selections from the Exhibitions of 1855 in Paris and 1862 in London; of the most valuable bequest ever made to the Museum—the collection of furniture, porcelain, and enamels of French 18th century work, left by Mr. John Jones, in 1882; and of the large collection of English pottery and porcelain given by Lady Charlotte Schreiber in 1884.

Italian sculpture has long been well represented, both by original work and by copies: and the Musum's examples of majolica and Della Robbia ware are world famous. Many of these, as well as other important works in the Museum, were selected by Mr. (now Sir) J. C. Robinson while on official visits to Italy, France, and Spain; and the most costly specimens of Majolica were purchased at the sale of the Fountaine collection.

Casts of Sculpture. — In 1884, an important addition was made to the Museum by the purchase of a series of casts illustrative of the history of antique sculpture, copies of the best examples in the principal continental galleries.

British sculpture and British architecture were, for a time, represented in the Museum, the former by a selection of examples shown at the instance of the Institute of Sculptors, now a defunct body, and the latter by a collection of 7,000 casts, chiefly Gothic in character, which had been collected by private interest in Cannon-row, Westminster, and which in 1867 were removed to the Royal Architectural Museum in Tufton-street.

Sheepshanks Collection. — British painting was first represented at the Museum in 1857, when Mr. John Sheepshanks presented a valuable collection of examples of the work of some of the best of England's painters—"with a view," to use his own words, "to the establishment of a collection of pictures and other works of art fully representing British art, and worthy of national support." It includes twenty-six of the finest works of Mulready, sixteen by Landseer, twenty by Leslie, and four by Turner: it has since been added to by several important bequests which cannot be mentioned in detail. The Vernon collection of British paintings and the Turner drawings, which are now in the National Gallery, hung for many years on the walls of the Museum.

Only a very small proportion of the money expended by the Department in purchases has ever been paid for oil paintings. The majority at present to be seen are either donations, or bequests, or loans as in the case of the pictures purchased by the Royal Academy out of the Chantrey Bequest, and which are lent by that body to the Museum, and from thence to certain provincial institutions of a similar character. They now number upwards of forty examples of painting and sculpture.

Water-colour Drawings. — The Museum contains the only national collection of British water-colour art, which, with the exception of the Turner drawings, is unrepresented in the National Gallery. If we could have a truly National Gallery of British Art—in which should be placed the English pictures, both in oil and water-colour, at South Kensington, and the British side of the National Gallery, supplemented by works of the many British artists who are represented at neither institution, and by the paintings bought under the Chantrey bequest—space would be made for more examples of ornamental and decorative art at South Kensington, and for the works of foreign schools in Trafalgar-square; and British painting would be fairly represented in the eyes of Europe.

Some of the remaining features of the Museum can only be touched upon lightly. The Keramic Gallery is filled with valuable examples of the pottery and porcelain of every nation, and is especially celebrated for its unrivalled collection of Henri Deux ware. And the textile fabrics comprise a rich and varied display, including the celebrated Syon Cope of the 13th century, and other ecclesiastical vestments.

Since their removal to the Museum from Hampton Court in 1865, the Raphael cartoons have unquestionbly proved of much greater value to art students; and it is to be wished that Mantegna's "Triumph," one of the finest works of decorative art in England, might be permitted to keep them company.

India Museum.—In 1879, the Museum was increased by the addition of the collections which had been formed by the East India Company and the India-office, and which were by the latter body handed over to the Department of Science and Art. These collections, supplemented by such Indian objects as the Museum possessed before, and by special purchases made in recent years, are placed in the galleries on the opposite side of the Exhibition-road.

Art Library.—The Art Library, for which rooms have recently been erected, is a very important feature of the Museum for art students. It contains upwards of 70,000 volumes bearing directly upon art, and, in addition, 240,000 drawings, prints, engravings of ornament, and photographs of art objects. The value of such a library in close proximity to the National Art Training School can be readily imagined. Here, allusion may fittingly be made to the "Universal Catalogue of Books on Art," which was compiled in 1864-5 by order of the Department, and which contains, with its appendix, 65,000 entries of books treating on the arts, and is, in fact, a universal record of printed art books known to exist at the period of its compilation, wherever they may have happened to be. The catalogue, if carried down to the present time, would of course be increased by many thousand entries.

Dyce and Forster Collections.—Connected with and yet — owing to the nature of the bequests—apart from the Art Library are the Dyce and Forster collections, comprising many valuable books of reference and prints, as well as paintings, drawings, and other art objects. The Dyce collection is noted for its first folio Shakespeare.

Exchange of Copies.—In 1863, it was decided that purchases in the fine arts should in the main be confined to those objects which have a tendency to improve art as applied to articles of utility; that the decorative work of all countries should be completely represented; and that where original works were not obtainable, electrotypes, casts, and drawings of the finest examples should be substituted. It was found possible in many instances to obtain these by exchange with institutions abroad, in accordance with a plan initiated in 1864, and first carried out with success at the time of the Paris Exhibition of 1867, when a convention for the purpose was signed by representatives of many of the reigning families of Europe. Amongst the principal copies which the Museum has obtained through this means of exchange may be mentioned those of Trajan's Column, Blondeel's Fire-place from Bruges, and Kraft's Sculpture from Nuremberg.

Loan Exhibitions.—One of the most important features of the Museum, considered either from a popular or an educational point of view, has been the series of special loan exhibitions held from time to time within its walls, which were a complete novelty in connection with institutions governed by the State. In 1853, the Department organised a special exhibition of furniture and of drawings by Mulready at Gore-house; in 1858, there was held in the Museum an exhibition of art manufactures, executed by students of the art schools; in 1862 a special loan exhibition comprised the finest collection of art objects belonging to private owners ever brought together; in 1865 there was a representative exhibition of miniatures; in 1870, fans were shown in profusion; in 1872, lovers of music were delighted by the collection of ancient musical instruments that were gathered together; in 1873, decorative art needlework was shown; in 1874, enamels on metal; in 1881, Londoners had an opportunity of becoming more fully acquainted with Spanish art, and in 1882 of Scandinavian; and in 1884, the Department organised at the Health Exhibition an important display of works by art students throughout the kingdom.

National Portraits.—A series of exhibitions of national portraits was also organised by the Department in 1866-67-68. They were very successful, and tended to increase the National Portrait Gallery, the pictures of which are at present located (till such time as a fitting home shall be built for them out of the funds, £100,000, provided by a munificent quasi-anonymous benefactor) in the Bethnal-green Museum, where they afford to the inhabitants of the East-end of London a means of becoming acquainted with the features of some of England's greatest men.

Loan Collections.—Special collections of objects of art interest have been from time to time temporarily lent to the Museum for the enjoyment and instruction of the public—such as the Prince and Princess of Wales's wedding gifts,* the Abyssinian treasure, the objects excavated by Dr. Schliemann at Troy, pictures from Deepdene, Althorp, and elsewhere, and latterly Mr. Salting's valuable collection of Chinese pottery, porcelain, Italian majolica, and Rhodian ware.

Photographs of Objects.—At an early time, the practice of taking photographs and making casts or electrotypes of fine objects lent to the Museum was commenced; many highly instructive objects have been acquired for the use of the students for all time, and the Department owns many thousand negatives available for the diffusion of artistic designs.

Catalogues and Handbooks.—It has been recognised at the Museum that to many visitors art objects, however well arranged, are in great measure a closed book unless accompanied by official aid. For this reason, each object is carefully labelled with full information as to its date and country; a general guide to the Museum is issued, and, above all, special handbooks are published on the various branches of the industrial arts, at prices accessible to all. Thus, if the student supply the will, the means of study are ready to his hand.

Circulation.—It was always intended, from the earliest times, that the objects collected in the metropolitan Museum should, as far as possible, be made available for the purposes of extending the knowledge of provincial and manufacturing towns, both in science and in art. No objects are, however, lent by the Department unless they can be supplemented by contributions from the neighbourhood; and free entrance is assured to students of any school where exhibitions are held. In addition to these temporary loans, objects are lent annually to thirty-six museums in connection with science and art schools, or under municipal authority, throughout the kingdom, of which the principal are Birmingham, Nottingham, Manchester, Sheffield, Bradford, and Wolverhampton. The system of making reproductions above referred to enables the scope of this system of circulation to be much more widely extended than could otherwise be the case; and for the purposes of instruction, a carefully-prepared cast or electrotype is in all essentials as serviceable as the original. Assistance is also granted to art and science museums by a contribution of half the cost of objects—chiefly reproductions—purchased with the sanction of the Department.

Buildings.—From 1857, votes were passed by Parliament for the purpose of building the South Kensington Museum and cognate institutions, making up till March, 1884, a total of £390,350. But owing in great measure to the limited amount granted each year, much still remains to be done; and at present many of the objects are crowded together, and thereby lose much of their usefulness. Repeated appeals to Government have failed to produce the grants necessary for the completion of the buildings. The unfinished appearance of the main entrance cannot but strike a visitor, especially a foreigner, as singularly inappropriate for the finest museum of its kind in the world, and the Exhibition-road entrance is also most undignified in character. The façade, which is intended to complete it, is well known from the model prepared by the late General Scott, to be seen in the museum itself. The earliest portion of the present building to be erected was the Picture Gallery, designed in 1856 by Captain Fowke and Mr. Redgrave, R.A., to receive the collection of paintings, presented by Mr. Sheepshanks; and so suitable was it found to be for the exhibition of pictures that its proportions have frequently been copied exactly for similar purposes, both in England and abroad. It has been pointed out that the successful use in the museum buildings of terra-cotta for structural purposes has played an important part in the adoption of that material in recent buildings.

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* The good effect of the exhibition of these wedding gifts is felt to this day, for a portion of the receipts taken while they were on loan was invested, and the interest is yearly given in the form of two Princess of Wales's scholarships to the two highest of the female students in the national art competition.

Bethnal-green Museum.—When it became necessary, in 1866, to remove the temporary iron buildings (or "Brompton Boilers," as they were popularly called) at South Kensington, to make way for the permanent structure, it was decided to utilise them in the construction of a branch museum at Bethnal-green, which, erected on a site contributed by the inhabitants of the East-end of London, was opened in 1872. It contains the animal products and food collections, and, as is mentioned above, offers a temporary home to the National Portrait Gallery. It has at various times been graced with private collections of much value, such as the paintings and furniture of Sir Richard Wallace; the pictures of the Marquis of Bute; and now the collection of European porcelain and Japanese lacquer, lent by the Hon. W. F. B. and Mrs. Massey-Mainwaring. The Jubilee presents of the Queen also were on exhibition there for several months, in order that her Majesty's subjects at the East-end might enjoy the advantages of seeing them, previously accorded to those of the west. Upwards of 10,000,000 persons have visited this museum during the seventeen years of its existence.

Museums at Dublin and Edinburgh. — The museums at Dublin and Edinburgh affiliated to South Kensington have already been referred to when considering the Science Section; but it may be here mentioned that as early as 1727 the art of design was fostered in Scotland by the formation of the "Board of Trustees for the Encouragement of Manufactures;" and that in establishing a branch school at Dumfermline for the special purpose of teaching the drawing of patterns for tablecloths, &c.; and in contributing half the salary of the master on condition that the local manufacturers should find the other half, they initiated that principle of partial assistance rather than absolute support which has since been so successfully carried out by the Department. It may further be noticed that the Royal Dublin Society claims to have been the first institution in the United Kingdom to offer premiums in encouragement of the arts; and its drawing school, founded as early as 1741, though now merged in that of the Department, has carried on its work without intermission for nearly a century and a half.

V.—CONCLUSION.

By means of the many exhibitions held, and the encouragement given in the art schools, there has doubtless, in the last quarter of a century, been a marked increase in the recognition of the fitness and beauty of good designs as opposed to poor and tasteless decoration. In England, artists, with few exceptions—such as Flaxman and Stothard—have rarely condescended to assist the art workman, and the system of education adopted has tended rather to try to educate the artisan up to the standard of the artist. Whether this plan is as successful for the final securing of the finest objects of art workmanship is open to question, though it is doubtless advantageous from a commercial point of view. But to have taught the nation at large to discriminate between the good and the false in design is no mean achievement, and the means by which the good designs are produced are in comparison a secondary consideration.

The history of the Department of Science and Art is so interwoven with that of international exhibitions at home and abroad that it seems fitting to here briefly refer to them. In 1855, the task of organising the British Section of the Paris Exhibition was placed in the hands of the officers of the Department, and Mr. Cole became Executive Commissioner, and ever since that time officers of the Department have had, unofficially, more or less to do with the holding of international exhibitions at home and the maintenance of British Sections abroad. Mr. Cole was also executive Commissioner in Paris in 1867; and Sir Philip (then Mr.) Cunliffe-Owen, who succeeded him as director of the Museum in 1873, represented England at Vienna in 1872, at Philadelphia—for a time—in 1876, and at Paris in 1878.

The Exhibition of 1862 was held on land granted by the 1851 Commissioners, and permanent brick structures were erected with a view to their being used for similar purposes later on; but the gallery which crosses the land from east to west is all that now remains.

In 1868, it was resolved to hold on this land a series of annual exhibitions, extending over ten years. Four only took place, 1871-74; and for them were erected the permanent galleries on the east and west sides of what was then the Horticultural Gardens. These undertakings were not financially successful. In 1851, the Prince Consort, ever anxious for the advancement of education, had strongly advocated the comparison of like things with like—that is to say, arrangement by classes and not according to geographical position. The difficulties, many of which are obvious, were considered insuperable, and the plan was abandoned, to be revived in 1871, when endeavours were made to carry out the principle. With some sections, such as pottery, jewellery, carriages, &c., the scheme worked well; but on the whole it was not sufficiently well supported. "I believe it," Sir Henry Cole says in his diary, "to be far more scientific and technically useful than the geographical system; but it is less picturesque and popular....It is a system quite suitable for a museum, and may be permanent in a museum; but it is not the best for an extemporised work like an international exhibition." Again he says, "the aim of these exhibitions was specially technical instruction, and nearest in analogy to that of the South Kensington Museum.....Dividing the whole deficit over the number of visitors, each visitor may be said to have cost the Commissioners twopence. Viewed as a contribution in aid of technical instruction this is trifling in comparison with the payment per visitor to the British Museum, which amounts to about four shillings per annum, whilst each visitor to the South Kensington Museum costs under eighteenpence." Subsequent experience has proved that an exhibition's popularity is by no means in direct ratio to its instructiveness.

After a lapse of some ten years, the land was again used for a cycle of exhibitions which are still in the minds of all—Fisheries, Health and Education, Inventions and Music, and in 1886 the Colonies and India.

No less than twenty-eight million persons have studied the collections in the South Kensington Museum since its opening in 1857; and, commencing with the Great Exhibition of 1851 and closing with the last named, upwards of thirty millions visited the ten exhibitions referred to as held through the means of the 1851 Commissioners; and they have thereby obtained more or less insight into the progress made from year to year in the arts, sciences, and industries, and have thus aided in fulfilling the wishes of the Prince Consort and the objects which he had in view when he invested the surplus funds of the 1851 Exhibition in the land at South Kensington.

On this land there now stands the South Kensington Museum, with its India Section, its Art and Science Schools, its science collections and ship models, and the Buckland Museum. To the north of the grounds is the Royal Albert Hall, erected in memory of the Prince Consort, and devoted to music, and the Royal College of Music, founded in 1873 as a National Training School, where teachers were trained in their profession of music, and which in 1882 was merged in the College, which is shortly to be much enlarged, at an expense of £45,000, given by Mr. Samson Fox, of Leeds. Next to it stands Alexandra-house, opened in 1883 as a home for lady students in the various departmental schools. On the east side are the Royal College of Needlework, and the Technical Institute of the City and Guilds of London, and at the southern extremity is the Natural History Branch of the British Museum. The Royal Horticultural Society, in which the Prince Consort took a deep interest, occupied a large portion of this land for many years, till 1888; and the National Training School of Cookery, which was designed, as a result of the Exhibition of 1873, to apply the principles of instruction in cookery throughout England on a plan similar to that adopted for science and art, only quitted, in 1889, its home on the east side, which it had occupied upwards of sixteen years. The Horticultural Society still retains its gardens at Chiswick, and the School of Cookery is located in new buildings in Pimlico.

On the centre of the ground is being erected the Imperial Institute of the United Kingdom, the Colonies and India, which is a more or less direct outcome of the Colonial and Indian Exhibition. Thus the whole of the land bought by the Commissioners of the 1851 Exhibition will be utilised for the furtherance of the object for which it was purchased—the advancement of education in science and art—though it is to be regretted that the various buildings could not have been erected with more consideration to uniformity. This irregularity has, however, been inevitable from the gradual development of the scheme.

MAT MANUFACTURE IN COCHIN.

The following account of the history and manufacture of Wadakaucherry mats has recently been given in a report on the Agricultural and Industrial Exhibition held at Mysore in October of last year.

The mats are made at Wadakaucherry, a taluk of Cochin. They are known at the place by the simple name of grass mats, and are recognised elsewhere by the name of Palghat and Kavalapasa mats, other places of manufacture. The industry was introduced into Cochin from Kavalapasa about forty years ago. At first there was but one family engaged in the trade, it has now increased to three, consisting in all of twenty souls. Both males and females are employed in the work. The men were originally brought for making mats from the Sircar, and were provided with free quarters. Such is the short history of the introduction of the industry into Cochin.

These mats are made, like the Palghat mats, of a kind of sedge (*Cyperus Pangorei*), grown by the side of swamps and rivers. The sedges grow to a height of six feet, by one and a half inches in circumference, and are of a triangular shape. They are collected in the rainy season. The culms or stems are split, and the inside pith removed, and are then dried. Each stem may be split into from four to eight, or even twelve, according to the delicacy of the texture intended. The strips are then well seasoned and sown into mats. Women are mostly employed in the collection and splitting of the stems, while the actual weaving is done by men. The loom used for the purpose is of simple construction, consisting of two bamboo pieces at either end, attached to pegs driven in the ground. The warp consists of twine made of country hemp, and is produced by the weavers themselves. In special cases cotton-thread is also used instead of twine. The process of weaving is done by the strips of sedge being passed to and fro crosswise, by means of a stick with a hole at one end of it to which the sedge is attached. The warps are passed through a moveable piece of wood with as many holes as there may be warps, and are tied up to the bamboo pieces at either end. According to the number and nearness of the warps the greater is the delicacy and strength of the texture. The woof is made compact by means of the piece of wood above described.

The distinguishing peculiarity of the Wadakaucherry mats is their brilliant colour. Only four varieties of it can, however, be had, namely, the white, black, red, and yellow; of these the last is the readiest to fade, and is obtained from a peculiar solution of turmeric and cassia leaves. White is the natural colour of the strips when properly prepared; red is obtained by boiling the strips in water containing sappan-wood and cassia leaves; black is but a conversion of red by a peculiar process of boiling the red strips in a solution of gall-nuts and green vitriol, and by subsequent soaking in a preparation of black clay. The difficult and dexterous portion of the work is the splitting and dyeing of the strips, the same has to be coloured with different colours, and this has to be done very carefully with reference to the size of ornamental work intended to be produced. When one colour is being worked at, the rest of the strip which has to be coloured differently will be closely covered with the outer covering of the plantain tree. The process of drying and dyeing the strips may take a fortnight.

Natives use the mats as seats, and also for mattresses in the hot weather. A sort of social distinction is associated in the offer of these mats as seats, and amongst the vulgar, disregard of it on ceremonial occasions tends to foment disputes. These mats are also used for flooring, and are then woven to the size of large halls and rooms. The mats vary in price from 1 to 10 annas, while the superior kinds fetch from 15 to 25 rupees, according to quality.

Experiments have been made with other colours besides those just mentioned, but hitherto without success. If the industry were carried on by organised capitalists, these experiments might perhaps be successfully repeated, and many other improvements effected, such as facilitating the splitting of the sedge and keeping it compact by means of mechanical aid, and also relieving the weavers from the stooping they have always to assume when engaged in the work.

The mats of Wadakaucherry, compared with those of Tinnevelly, are generally superior in colour and ornamental work, but are less pliable, though the strips are sometimes more delicate.

Notes on Books.

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THE COLONIAL YEAR BOOK FOR THE YEAR 1890. By A. J. R. Trendell, C.M.G., with Introduction by J. R. Seeley, M.A. London: Sampson Low, Marston, Searle, and Rivington.

This volume contains a full account of the history and growth of the various colonies, these colonies being arranged in alphabetical order, beginning with Aden and ending with Zululand. Besides the historical information contained in the Year Book, the latest statistics are given, and the names of the officials, as well as the postage and telegraphic rates, &c. In the appendix the various institutions connected with the colonies are described. Professor Seeley, in his introduction, shows how this vast colonial empire has grown up, how its periods have changed, and how great have been its viccissitudes. Milton saw with the eye of a prophet what this colonial empire would be when he pictured England as standing "with all her daughter lands about her."

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

APRIL 16.—TALBOT B. REED, "Old and New Fashions in Typography." Dr. GARNETT, Keeper of the Printed Books in the British Museum, will preside.

APRIL 23.—WILLIAM WHITAKER, F.R.S., "Coal in the South-East of England." ARCHIBALD GEIKIE, LL.D., F.R.S., will preside.

APRIL 30.—T. R. DALLMEYER. "Photographic Lenses."

MAY 7.—DR. PERCY F. FRANKLAND, "The Aim and Scope of Higher Technical Teaching."

MAY 14.—Dr. J. A. FLEMING, "Prof. Elihu Thomson's Electro-Magnetic Induction Experiments."

MAY 21.—J. G. GORDON, "The Mannesmann Process for making Seamless Tubes."

FOREIGN AND COLONIAL SECTION.

Tuesday afternoons, at Five o'clock:—

APRIL 22.—SIR JOHN STOKES, K.C.B., "The Danube and its Trade." Sir ARCHIBALD ALISON, Bart., G.C.B., will preside.

MAY 20.—A. LASENBY LIBERTY, "The Industrial Arts of Japan."

INDIAN SECTION.

Thursday afternoons, at Five o'clock:—

MAY 22.—SIR J. THEODORE HOPE, K.C.S.I., "The Rationale of Indian Railways." The MARQUIS OF RIPON, K.G., will preside.

[The Meetings of this Section have been changed from Fridays to Thursdays.]

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock :—

APRIL 15.—C. PURDON CLARKE, C.I.E., "Modern Indian Art." Sir GEORGE BIRDWOOD, M.D., K.C.I.E., C.S.I., will preside.

MAY 13.—Prof. W. C. ROBERTS-AUSTEN, F.R.S., "The Use of Alloys in Art Metal-work."

CANTOR LECTURES.

Monday evenings, at Eight o'clock :—

RICHARD BANNISTER, "Sugar, Tea, Coffee, and Cocoa, their Origin, Preparation, and Uses." Four Lectures.

April 28; May 5, 12, 19.

ADDITIONAL LECTURES.

Thursday evenings, at Eight o'clock :—

LEWIS F. DAY, "Design applied to Wood-Carving." Three Lectures.

May 1, 8, 15.

The regulations for admission will be the same as for the Cantor Lectures, each member having the privilege of admitting a friend.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, APRIL 14...Engineers, Westminster Town-hall, S.W., 7½ p.m. Mr. William Henry Brothers, "Weighing Machinery and Automatic Apparatus in connection therewith."

Surveyors, 12, Great George-street, S.W., 8 p.m. Discussion on Mr. T. W. Wheeler's paper.

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Dr. Hans Meyer, "Journey to the Summit of Kilimanjaro."

British Architects, 9, Conduit-street, W., 8 p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m.

TUESDAY, APRIL 15.. SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m. (Applied Art Section.) Mr. C. Purdon Clarke, "Modern Indian Art."

Royal Institution, Albemarle-street, W., 3 p.m. The Hon. G. C. Brodrick, "The place of Oxford University in English History." (Lecture I.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Sir Frederick Bramwell, "Application of Electricity to Welding, Stamping, and other Cognate Purposes."

Pathological, 20, Hanover-square, W., 8½ p.m.

Photographic, 5A, Pall-mall East, S.W., 8 p.m. Mr. C. H. Bothamley, "A Standard Method of Development."

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Mr. A. Smith-Woodward, "Some New Fishes from the English Wealden and Purbeck Beds, referable to the Genera *Oligopleurus*, *Strobilodus*, and *Mesodon*." 2. Mr. G. A. Boulenger, "Second Report on the Additions to the Batrachian Collection in the Natural History Museum." 3. Mr. Frank E. Beddard, "The Structure of *Psophia*, and its Relations to other Birds." 4. Mr. R. Lydekker, "A remarkable Antler from Asia Minor."

Colonial Inst., Whitehall-rooms, Hôtel Métropole, Whitehall-place, S.W., 8 p.m. Sir Arthur Hodgson, "Australia Revisited."

WEDNESDAY, APRIL 16...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. Talbot B. Reed, "Old and New Fashions in Typography."

Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Mr. Charles Harding, "The Cold Period at the beginning of March, 1890." 2. Mr. J. E. Clark, "Note on the Whirlwind which occurred at Fulford, near York, March 8th, 1890." 3. Mr. Albert E. Watson, "On the possibility of Forecasting the Weather by means of monthly averages." 4. Mr. W. B. Tripp, "Rainfall of the Globe."

Geological, Burlington-house, W., 8 p.m. 1. Prof. A. von Könen, "Notes on some of the Palæozoic Rocks of North-Western Germany." 2. Dr. J. W. Spencer, "On the Origin of the Basins of the Great American Lakes." 3. Mr. R. Lydekker, "Ornithosaurian Remains from the Oxford Clay of Northampton." 4. Mr. D. Pidgeon, "Certain physical phenomena exhibited by the so-called 'Raised Beaches' of Hope's Nose and the Thatcher Rock, Devon." 5. Mr. J. C. B. Hendy, "Notes on a 'Wash-out' found in the Pleasley and Teversall Collieries, Derbyshire and Nottinghamshire."

Microscopical, 20, Hanover-square, 8 p.m. 1. Mr. W. West, "Freshwater Algæ of North Wales" 2. Mr. M. M. Hartog, "The state in which Water exists in live Protoplasm."

Archæological Association, 32, Sackville-street, W., 8 p.m.

Patent Agents, 19, Southampton-buildings, W.C , 7¼ p m. 1. Mr. Lloyd Wise and Mr. Herbert Lapage, "The Argentine Republic as a Field for Invention." 2. Mr. A. P. Jones, "Trade Mark Practice." 3. Mr. E. Morton Daniel, "The Proviso to Section 32 of the Patents Act, 1883."

North-East Coast Institute of Engineers and Shipbuilders, Newcastle-on-Tyne, 7¾ p.m. (Graduate Section.) 1. Discussion on Mr. B. Bramwell's paper, "Steam-engine Trials." 2. Mr. R. L. Weighton, "Application of Trial Results to Estimating."

THURSDAY, APRIL 17...Royal, Burlington-house, W., p.m. 4½.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m.

Chemical, Burlington-house, W., 8 p.m.

Society for the Encouragement of Fine Arts. Second *Conversazione* at the Galleries of the Royal Institute of Painters in Water Colours, Piccadilly, 8 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Prof. C. V. Boys, "The Heat of the Moon and Stars." (Lecture I.)

Historical, 11, Chandos-street, W., 8½ p.m.

Numismatic, 4, St. Martin's-place, W.C., 7 p.m.

Archæological Institution, Oxford-mansions, Oxford-street, W., 4 p.m.

FRIDAY, APRIL 18...Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Sir Frederick Bramwell, "Welding by Electricity."

Philological, University College, W.C., 8 p.m. Rev. Prof. Skeat, "English Etymologies."

Quekett Microscopical Club, 20, Hanover-square W., 8 p.m.

Physical, Science Schools, South Kensington, S.W. 3 p.m.

SATURDAY, APRIL 19...Royal Institution, Albemarle-street, W., 3 p.m. Capt. W. de W. Abney, "Colour and its Chemical Action." (Lecture I.)

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FRIDAY, APRIL 18, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

PRACTICAL EXAMINATION IN VOCAL AND INSTURMENTAL MUSIC.

The next examination in London will be held by W. A. Barrett, Mus. Doc., at the House of the Society of Arts, and will commence on Monday, 2nd of June.

Full particulars can be obtained on application to the Secretary.

Proceedings of the Society.

APPLIED ART SECTION.

Tuesday, April 15, 1890; Sir George Birdwood, K.C.I.E., C.S.I, LL.D., M.D., in the chair.

The paper read was—

MODERN INDIAN ART.

By C. Purdon Clarke,
C.I.E., M.R.I.B.A.

Many travellers, especially those who visit India expecting to find treasures of Oriental art at every turn, feel a very deep sense of disappointment when landing either at Bombay, Madras, or Calcutta. They find, first of all, European-looking cities, and then, after with some difficulty arriving at the bazaars, rows of shops anything but Oriental in appearance, generally filled with German or Manchester goods. Nor is this disappointment lessened when they are visited by the pack-merchants or are examining the few *curio* shops, in which are found precisely the same series of goods we are accustomed to in the shops of the Indian importers in England. Then travelling through the country, the impression is deepened when at town after town apparently the same packages of wares are displayed, and the traveller begins to think that India, although a large country, possesses very little diversity in its art manufactures. These goods —for they can no more claim to be called works of art than the Manchester goods of the bazaars—soon lose their interest from the sameness of their meretricious ornamentation, and it is only when, here or there, some very fine object stands clear from the mass that it is inferred that the articles shown for sale are but a selection made for strangers, and that the real Indian art work is jealously kept out of sight for native use.

It is soon noticed that the local styles do not seem greatly to influence the markets for these ready-made goods, which in the design, workmanship, and quality of the material, are generally slovenly and inferior, and when bought and brought home, compare unfavourably with similar goods made only ten years before. When placed with the objects sent to the 1862 International Exhibition in London or that of 1851, the difference is so marked that the modern productions seem but copies made by another race and for other purposes.

I do not propose in this paper to in any way give a list of the localities producing Indian art wares. This information can be obtained in the works of Sir George Birdwood on "The Industrial Arts of India;" in Mr. Mukharji's very useful list of Indian manufactures, compiled from the latest information furnished by the Revenue and Agricultural Department at Calcutta, and in such special and local works as Dr. Hendley's book on "The Art of Jeypore," his more recent work on "The Arts of Ulwar," the "Indian Art Journal," as well as many monographs and gazetteers dealing with the subject. My task is to describe, as briefly as I can, the modern aspect of Indian art manufactures; the causes which have led them to take their present degraded form; and to make a few suggestions respecting the improvement of their present position.

The modern aspect of them is, as I have already stated, far from encouraging, and if it was not that there are certain elements of regeneration, which only require assistance to fulfil their work, I should be inclined to leave the whole subject alone, and not waste my own time nor yours with useless regrets. Therefore I will begin with the causes of the present debased position of the arts of India, my remarks on which, I trust, will be accepted in the same spirit in which they are made, my only wish being to save to posterity what we received from our ancestors, and to free ourselves from being blamed in the future for having recklessly destroyed those features of Oriental life which, amongst many disadvantages, constitute its special charm.

The arts of India, in which we are most interested, are, like ourselves, aliens to the country; they belong more to the military splendour of the conquering Mongols than to the pastoral simplicity of Aryan Hindu life. The period of Roman and Greek history which left such glorious remains in Europe is scarcely represented in India by existing monuments or works of importance, and, setting architecture aside, it is only by rich arms, metal, glass and jade vessels, woven and embroidered stuffs and such like objects, from the time of Akbar, that we form the standard by which modern Indian art can be judged; and a glance into the history of that period is sufficient to show how very unfair it is to compare the objects produced under such very different circumstances with the ready-made goods offered to travellers by the *boxwallahs* and merchants of the Indian cities.

We do not know how far it was the system of Hindu princes to maintain in their Courts artificers of various trades, but as it is the custom amongst the higher class of Hindus to have many things made in their houses, either by members of their own family or workmen hired for the purpose, it is probable that the princes maintained a staff of workmen always engaged in producing for the Court. But as several of the Hindu princes use the Persian "Karkhaneh," or workshop, for this portion of their establishment, it may be that this custom was only introduced in imitation of the Moghul Court. It was in these royal *karkhanehs* that all the great work was done, and as these artificers were allowed to work for outsiders rich enough to pay them liberally, a very high standard of excellence was set, which the small workers of the bazaars tried to emulate.

Very much of the high quality of the work may be attributed to two great causes. Time was not of the slightest object, as the workmen were in receipt of regular allowances, and even their families were supported. Each of these Courts also had what might be called a committee of taste in the leading artificers themselves—such as the master builders, jewellers, caligraphers, illuminators, and seal engravers—who were often professional draughtsmen, thoroughly skilled in the scientific as well as the artistic branches of pattern design.

There is no greater mistake made by many writers on Oriental art than that of asserting that the knowledge of ornament is instinctive with this or other Oriental nations. Speaking with more than twenty years experience as a teacher and a traveller, I can confidently assert that everywhere there is about the same average of people who can draw and design instinctively. In some countries there are better opportunities, or a condition of affairs more suitable to the development of art; but in the individual the quality we denominate "good taste" and its opposite "vulgarity," are both fairly meted out irrespective of position or race.

There is also not that diversity of design which is so often mentioned in relation to Eastern ornament. On the contrary, although it is difficult to find two objects exactly of a size, yet there is very little variety in their forms or surface decoration.

These Eastern peoples have done in remote antiquity what we attempt from time to time, that is, to lay down rules for the regulation of form and colour in ornamental decoration. These are known to have existed amongst the ancient Egyptians, and a canon of proportion was settled by the ancient Greeks, and certainly exists in the art of the modern Greek and Russian Church. The Silpashastras of India not only refer to building, but also give rules for the preservation and reproduction of the forms and features of their gods, and use secret means for burying these ornamental forms in simple lines of writing, from which every curve and feature can be reproduced by anyone knowing the key.

Mr. James Wild, when studying in Egypt, nearly fifty years since, found the Arab workmen producing geometrical designs by empirical means, rules of thumb; and Mr. Crace, some years back, in Damascus, was shown books of similar design which, however, he was not allowed to acquire. A few years later, in Persia, where I was completing the building of the Embassy, my workmen brought me, secretly, curious book rolls of design, both for plans and buildings, and every kind of ornamental decoration, floral and geometrical. These were not shown to people outside of their trade, but were learnt by the men, who apparently invented beautiful designs when called upon to show their skill. When at Jeypore, Major (now Colonel) Jacob showed me some patterns with rule of thumb methods for producing the curves of the ogee or cusped arches similar to those I had seen in Persia, and in Cashmere I came across certain bundles of paper closely covered with columns of writing in secret character, which a weaver could transform into the curve and colour of floral forms, or inversely; if given a design—no matter how complicated—he could translate it into these columns of written character.

All these belonged to the old system under which the Oriental arts were produced and perpetuated; and the high quality of the work was due to a slow development of the style in cultured hands, working their very best in court and temple for the approval of princes and the blessing of the gods. From this state of things we come to the totally different condition under which modern art exists, and, therefore, we should not wonder if, with causes so different, the results should not be the same.

Analogous changes have been at work all over the world, and if we look at home also it is easy to see that the arts of the past have very little in common with this positive, scientific nineteenth century.

In a few places, such as Jeypore, Ulwar, and Vizianagram, royal *karkhanehs* still exist, but somehow, owing to a mistaken sense of their utility, they could be scarcely said to be producing works of art, except at the Ulwar Court, where much decorative work is going on, and I found there a bookbinder who stated that his family had been in the Palace at Delhi from the time of Shah Jehan, and when driven out after the Mutiny they had been taken under the protection of the Rajah of Ulwar, a very intelligent and liberal-minded prince.

At Jeypore the *karkhaneh* had developed into a School of Art, in charge of a very well-intentioned Bengali gentleman, who, however, seemed to try to make it self-supporting, and consequently its productions were wanting in the true artistic character.

In Cashmere the late Maharajah took great interest in all art matters, as at that time a very considerable falling off in the export of shawls, one of his principal sources of revenue, was the cause of great anxiety to him. Here other influences were destroying the art qualities not only of the shawls but of other productions for which the valley is historically famous, and although the Maharajah spent enormous sums in promoting the local arts, everything was ruined by the use of designs sent from Europe. When there in 1882, I found standing in strong contrast with each other the most beautiful stuffs, made for Persia, Turkey, and Russian Asia, and the most hideous I had ever seen, ready for export to Paris and London.

It is in this factor of modern European influence that the whole matter rests, for although in the great 16th and 17th centuries this influence was very strong, yet it produced but little evil effect. The Dutch and Portuguese left traces of their art in buildings which are neither better nor worse than those in their own countries, and in furniture which stands far away above any in which we have any share of the design.

It was only towards the close of the last century that we began to leave our mark on Indian art. This we did by first of all attempting, as far as possible, to stamp it out, as we had succeeded in doing with our national Gothic and Elizabethan styles at home, substituting for it a bald and cold so-called classical style which, in our houses, was about as far from the actual dwelling-houses of Greeks and Romans as it was from the beautiful Oriental exteriors and interiors we were endeavouring to supersede.

Instead of this paper, it would require a heavy book to describe our various attempts at raising monuments of shame for ourselves in India. And after running the gamut of the styles in Greek, Strawberry Hill Gothic, and representations of the several periods of Pointed architecture in colleges and churches, we eventually woke up to the fact that India had a style more suited to the country than any of those we had tried to introduce, and, without waiting to consider, at once started people who had little previous experience or education in Oriental design to erect important works, which, though certainly far more appropriate than any of our previous efforts, yet, unfortunately, will remain—as they are generally very well built—for a very long time as records of our want of appreciation of the essentials of Eastern art.

Not in architecture alone but in other ornamental arts has the same blind course been followed.

For more than twenty-five years Schools of Art have been established in different parts of India, and for a time their influence was most disastrous, although it was impossible to have procured better men as directors than the Government was fortunate enough in selecting. In all cases the directors of these schools were most enthusiastic about native art, but, unfortunately, they were fettered with a two-fold chain. On the one hand, they had in a manner to follow our system of art education, which, do what we can, turns out more painters than designers; and, secondly, they had the wrong material in their students, and were cut off from the assistance of the master craftsmen of the art trades, whose system of teaching was radically different from our own academic course.

As in Europe in the Middle Ages, drawing was taught in every workshop in India, and every apprentice soon became skilled in the delineation of the ornamental forms used in his craft. He had no general education in drawing or ornament beyond this, therefore his mind was free from uncertainty and weakness in the treatment of his work. Here and there a clever man would introduce some slight change or improvement; and, if this was really good, it held its own, and was adopted by others, and thus the style slowly developed. Every detail in ornament had its special name, often apparently fanciful, but always with some hidden or symbolical meaning. There were quaint histories attached to many, and an unbroken thread of meaning running through all prevented any great alteration or interference.

As the apprentices learnt to draw, sometimes with their fingers on the sanded floor, or with charcoal on a tracing board, they simultaneously learnt to use tools, whether chasing in metal, carving in wood, or weaving on a loom; and with this knowledge of what the tool could do always in their minds they did not depict upon paper inappropriate forms, or those impossible to be artistically rendered in the material they were treating; and the whole individual mind being concentrated on the one particular class of work, there was the necessary emulation amongst the fellow-craftsmen to perfect it.

But our earlier School of Art system changed all this. Drawing was taught independently of its application to any particular art; a jumble of styles, Greek and Gothic, and pictorial representations of natural objects, launched them on a sea of undigested ideas, without the restrictive rudder of the requirements of any one handicraft to guide them. All the workshop lore, the rule of thumb methods, and valuable tradition were absent, and replaced by vague ideas of a possible rivalry with Europeans in European processes, to be rewarded by a European scale of pay.

Against this system the later School of Art masters had to struggle, and Bombay, Lahore, and Madras did so with some success by turning their schools into art workshops, where the pupils learnt and practised ornamental handicrafts, as well as drawing; and there is no doubt that had there been any combined system of working together, or had the Government shewn the slightest true consideration for them, a very great success might have been secured, as also with respect to the great jail manufactories of carpets. But all the Government really cared for was to make their art workshops self-supporting, and, therefore the superintendents were forced to work down to the level of mercantile people who only wanted cheap goods.

I do not wish in any way to blame the superintendents of these institutions, on the contrary; they have only done their duty, and I believe they have been in constant strife with the authorities in trying to bring about a better state of things, and invariably with the same result, that when, after several years insistence, they at last succeeded in getting a consideration of their proposals from the Central Government authorities — who, in India, rule all matters—the short term of office of the high officials expired, and the superintendents had to start all over again. Or worse, when after continued insistence, some important proposal was admitted—as for instance, that the carpets made in a jail should be only of patterns approved by the Director of the School of Art—the order remained a dead letter, as the jailers, working only for commercial results, refused to allow any interference in the case of patterns from Europe or selected from the jail sample book.

There is no absolute necessity for our Indian jails to manufacture carpets; but if the Indian Government looks to their manufacture as a source of revenue, bare commercial instinct ought to show that any little trouble in the matter of getting competent people to select patterns would be amply repaid.

The advance—and there has been a decided advance—within recent years in the quality of the design for these carpets, was entirely owing, first of all, to the care of the firm of Messrs. Vincent Robinson and Co., who collected old patterns and had them executed by the old free weavers in different parts of the country, and afterwards to Mr. Robinson's beautiful book on carpets. Much has also been due to the representatives of some great French and American firms who sent high-class old Persian and Turkestan patterns with large orders to the jails, binding them, however, to work for their especial markets. More recently the old carpets in the Feresh Khaneh at Jeypore have served as copies. These Dr. Hendley dug out and rescued from piles of rotting tents in the palace stores. Also the 16th century carpets at the Assar Mahal at Bijapur have been and are copied by some of the Bombay jails, and greatly appreciated on the Continent, where fine carpets are better understood than with us.

This art having almost become the monopoly of the jails, is passing out of the category of Indian handicrafts, as the free workers, finding no market for bespoke goods, are compelled to make cheap carpets for second-class trade. Pile-carpet weaving had always been a royal trade in the past. It was not amongst the indigenous arts of India, but introduced by the Moghuls, and one of the benefits conferred on India by the great Akbar was, in his own estimation, the introduction of carpet weaving.

In glazed pottery we have another art which is in no way indigenous, although it is probable the Hindus have been the largest makers and users of earthenware in the world, their religion causing them to continually discard or break earthen cooking vessels after use. Yet the art pottery of the country (for the earthen pottery never rises to that level) is entirely of foreign origin, and Mr. Mukharji's assumption that glazed pottery is an art introduced from China through Persia is not very far wrong, except when applied to the enamelled architectural pottery of the Panjab, which came in through Persia from Assyria.

Of this architectural pottery we know a great deal, as it can be found in a good state of preservation on buildings in Scinde and the Panjab, and we are enabled to compare qualities of this art so far back as the 16th century; but of pottery for domestic use, probably owing to its inferior quality, very little has survived, and, personally, I am not aware of any pieces which could be well dated before the present century. It was entirely a Mohammedan art, and, I believe, practised for the lower middle classes who could not afford the more costly porcelain of China, of which enormous quantities were sent to India in old times. The poorer Mohammedan people, not being able to purchase the real porcelain, used home-made imitations of it, and this in some parts of the country, as also in Persia, became fairly close imitations of the Chinese originals, the material being not earthenware but silicious frits. This semi-porcelain is at present only produced at Delhi and Jeypore.

The modern glazed pottery of India must have been very artistic at the beginning of the present century, some very fine pieces from the newly-conquered province of Scinde having attracted attention at the 1851 and 1862 Exhibitions. Shortly afterwards the manufacture of Scinde pottery was started by the School of Art at Bombay, when at once the demand for novelty caused the Principal to forsake the old landmarks, and thenceforth, as with all modern art goods made in large commercial quantities, very fine pieces seemed only to be produced by accident. The School of Art factory, however, effected one good work; by continually sending samples of pottery to exhibitions its wares were advertised and a demand created, which has been sufficient not only to keep the factory going, but also to revive the almost extinct kilns of Scinde.

More recently, the Bombay potters have struck out a new path and, abandoning the Persian ornament of Scinde, have taken their decoration from the fresco paintings of the Ajanta Caves, sometimes producing very happy effects; but it is a question whether the style of decoration used is really suited to its purpose, for, although imaginative and free, it seems to fail to command the sympathy which the more conventional Saracenic style always seems to exact.

At Madras much pottery is still made for Hindu use, and some fairly pretty green glazed ware was formerly sent to London from Arcot. But a very important step has been taken by the School of Art, where the late principal, Mr. Chisholm, not only succeeded in producing good stoneware but some actual porcelain. Here a fair amount of art pottery is made, but, although the designs are tasteful and the colours harmonious, there is a want of Oriental character in the ware which all the efforts on the part of the designers do not seem able to surmount. It is certainly the best made pottery in India, but, like every other Madras art manufacture, it is at present too expensive for the English market.

The *kashi* pottery of Delhi and Jeypore, already alluded to, should have a good future. All that is required is some little knowledge of proper glazing and the use of old Persian forms and decoration. The glazing, twenty years ago, of Delhi pottery was much better than it is now, and the Jeypore pottery, which is most carefully prepared, can scarcely be said to be glazed at all, and as a depth of tone and richness of colour in ceramics entirely depend upon the glaze, there are still most essential points to be secured before a good result can be attained.

I need not allude to the unglazed pottery of the North-West, especially to the rubbish which was, ten years ago, and, I fear, is still produced at Alligurh and Lucknow, of which it is sufficient to say that the most favourite example is a representation in half-baked clay and wire of a silver centrepiece, representing two camels under a palm tree, the whole daubed over with talc or silver paint. This, I believe, is an attempt at the reproduction of an electroplate atrocity from the illustrated catalogue of the 1851 Exhibition, and it certainly has been found by the potters to be what in shop language is called "a good line of business."

The glazed pottery in this Province is pretty, though weak, and consisted principally of plates and "chillum" pipe bowls; but latent strength exists amongst the potters, and this was shown by one of them at Kourja, who, encouraged by Mr. Grouse, the local officer, to send to an exhibition some glazed ware, was very successful, and soon started a fairly large trade.

Last of all is the glazed ware of Peshawar, which for a long time retained the quality of good, bold design and well-chosen colours, but popularity soon destroyed the simplicity and naturalness of the art, and the potters—who were perfect so long as they attempted only such ornament as they understood—fell into mere vulgarity when producing imitations of higher styles beyond their comprehension.

The truly native Hindu unglazed earthenware was never intended to rank amongst art wares, and, therefore, there is nothing in India to correspond with the sepulchral pottery of the Greeks or Romans. Yet all over the country can quaint and sometimes decorative forms be found, but they seldom are good enough to repay the trouble of sending home.

Another art, that of cotton-printing, is in very much the same position as pottery, having been introduced by the Moghuls, and principally for use by the middle classes in place of more costly brocades and rich embroidered stuffs. This art, so long as it was left alone, did not greatly deteriorate, and very probably would have died a natural death with all its glories about it—killed by the competition of Manchester printed goods, which, not only destroyed the home market, but also took from the Madras printers their Persian trade. But before the art was quite extinct a small trade with Europe has been revived principally owing to the demand created by the Universal Exhibition of 1878. Unfortunately this demand has led, as a matter of course, to the production of cheap work of inferior quality, in many cases only a semblance of printing being attempted, the colouring being produced with ordinary water-colours, not in any way dyed oa fixed.

Thorough work was formerly done at and near Lucknow, that is, high-class chintz printing, capable of cleaning and washing. Again, Jeypore and other places in Rajputana, Tatta, and Scinde, and several towns in the Bombay Presidency also produced washing prints; but for excellence of work none equalled the printing of Masulipatam, where a large colony of Persians was established, manufacturing, first of all, for Persian trade, and, secondly, for Moghul use in India. These men used the most elaborate processes, and produced a class of goods which equalled the work of the loom in appearance and in price. No transferring of colour by block would ensure effects sufficiently permanent in all the tints they required, so they used the process of printing by reserves, known as *kallam kar*, in which the leading work is the use of a pen charged with liquid wax for stopping patterns, leaving the ground of the design to be coloured in the dyer's vat. Of these there are examples in the India Museum, showing that, to produce the colours, the whole surface not covered by the tint in question has been each time carefully painted by hand, with wax. This is a costly and delicate operation, especially where, in some cases, the points of the design left unprotected consisted only of fine lines and dots.

Of ancient Indian metal work, more examples have survived than those of several other arts, but here, again, the most beautiful belong to, and show Saracenic influence. With the exception of vessels made for religious purposes, the Hindu brass and copper work is plain in form, and seldom decorated, owing to the necessity for constant cleansing. The first which attracted any attention in England were the productions of the Benares brass workers, who prepare, for sale to travellers, quantities of ornamental vessels, Saracenic in form, but covered with Hindu decoration in chasing. These men, being ignorant of design, had to rely entirely upon the covering of their ground by closely packed minute work. This work failing to catch the eye at any one point, attention was not called to its want of meaning. It was very popular for a long time, until it was rivalled by the workers of Moradabad, whose productions were first sent to Europe by Mr. Rivett-Carnac in 1878. This was somewhat better than that of the Benares, and pleased principally from the quality of neatness of execution; and here and there the artisans showed that if encouraged they could really produce high-class works of art, by sending vessels covered with splendidly drawn and appropriate floral ornamentation. One thing, however, was required, and that was the general improvement of the forms of the vessels worked on; but, instead of this, the dealers, searching after novelty, went off in another direction, and introduced polychrome decoration, causing the total decay of the art.

This introduction of several coloured pastes, instead of enamel, in chased metal work was formerly in use all over the East, and often produced most artistic results. I have seen a few old pieces where several colours were used with great success, but every modern attempt up to the present time has been a failure, generally owing to the vulgarity of the design used in conjunction with this coloured inlay.

During the ten years or more that these localities have been producing work deficient in leading art qualities, in many parts of the North-West Provinces fine bold and exceedingly ornamental examples of hammered and chased copper and brasswork have been made for native use, which, though freely exposed in the shops, escaped observation, and to this day have not been in any way utilised by our people. These are generally met with in the form of spice boxes and hookah bases, and if compared with the Benares and Moradabad it will be at once seen that Indian artisans, when working for native use, make few mistakes; no unmeaning small ornament is attempted, but only good bold designs are produced, freely handled and properly applied.

Next we get to a special school of decorative art, the history of which would be very interesting if it could in any way be traced, and this is the copper-working for the covering of the Golden Temple at Amritsar, milar in its details to the wood-carving in the same locality. Some of this work is probably a hundred years old, but whether of the last century, or of fifty years, or ten years back, or of the present day, this art goes on without the slightest change. This is most fortunate, as the only change would be for the worse, it being impossible to do better in metal. These workers at Amritsar certainly merit some notice, though I fear that notice may do them more harm than good. Here we have precisely the conditions under which the great art works of the middle ages existed. These craftsmen, like those of old who worked at Ephesus on the silver shrines for Diana, are engaged in producing plates of ornamental work, which the pious are allowed to place on the temple, about the sacredness of which they have not the slightest doubt. Again, they have another advantage in working for a higher religion, that of the Sikhs, which is not connected with any degrading form of worship necessitating horrible and grotesque symbolism. Also they have before them in this temple, which has been so slowly perfecting, examples of high-class work produced by their forefathers. As they do not work for a middleman, the whole value of their labour is received by them, and the result is so obvious that it is not necessary to be an expert to see that they put their whole heart in their work.

We next have the metal work of Cashmere, which, at the beginning of this century, had much in common with that of Turkestan and the north of Persia; but there came a period when French influence showed itself through all their art industries, and ruined everything. Not that the French in any way Europeanise—that is not one of their faults—but, in their usual fashion, they caught hold of one or two features of the local style, and insisted upon their mechanical repetition *ad nauseam*. Their coffee-pots and teapots, vases, and other forms in gold, silver, and copper vessels, all repeated the same Cashmere shawl decoration of the cone pattern. In old examples, both of shawls and of metal vessels, in the India Museum, these cones are comparatively rare. Within the last few years, however, principally owing to the large prices given for old vessels—for which Cashmere has been thoroughly ransacked—the dealers and metal workers have taken to copying them, and at recent exhibitions some of the best pieces of metal work have been of the revived Cashmere style.

Last of all, we have the metal work of the south of India. Here are many quaint forms, the localities of which are still unknown to us, and here and there in the temple lamps and vessels, both Hindu and Christian, great skill is shown in casting bronze, but to the present day very little encouragement has been given by trade except to what is probably the very worst and most meretricious Anglo-Indian art manufactures of the country, the Tanjore encrusted vessels. These commencing in a legitimate and harmless form, have, owing to a vicious direction, become examples of bad taste in vulgar ornamentation.

The art of encrusting copper and brass with silver and copper seems to have been practised for a long time in Southern India both by Hindus and Mohammedans; the Hindus even had a process, which I think is peculiar to them, of casting figures in the one metal with raised ornamentation in another—all in one operation. Old examples of encrusted vessels are rare and highly prized, and the Tanjore work of twenty years ago had still considerable merit, although the *swami* figures were even then becoming too pronounced. The mischief was owing, I have no doubt, to British influence, our people insisting upon more elaborate work. In a similar manner we have destroyed the art of the Burmese silversmith. The relief being forced higher and higher, the ornament becomes more confused until, finally, the outline of the vessel is lost, and an object is produced utterly unfit for any use except to be shown under a glass shade.

The arts of stone and wood working are in India very closely connected, both in Hindu and Moghul architecture. The two very different modes of construction are so mixed, and borrow so much from each other, that it seems almost a principle that the masons treat stone like carpenters, and the carpenters use wood after the fashion of masons, in solid masses, depending upon weight for stability. The modern form of both arts, excepting in Nepaul and the extreme south, has become distinctly Saracenic, retaining always certain peculiarities of the Hindu style, which stamp it with a distinct character, and separate the Hindu Saracenic style from all other varieties of Mohammedan architecture.

In England we are best acquainted with Indian wood-carving in the well-known Bombay furniture, the Surat carved sandal-wood boxes, and the more refined work of Kanara and Mysore, but in these changes have, within the last few years, distinctly altered the style, and not for the better. The application of Oriental ornamentation to European-shaped articles of furniture was probably introduced by the Dutch and Portuguese, and such old pieces are found worthy of comparison with those of the Renaissance in Europe; but these are seldom later than the close of the last century, when the Empire style and the variety of revived classic art, practised by the Adam Brothers, had a marked influence over all furniture produced in our Presidency towns. Both being based upon vigorous styles produced a corresponding effect, and it is evident that the Europeans, who must have had some part in the designing of these pieces of furniture, were people who had knowledge of construction for cabinet work. These patterns were repeated during the first half of this century (but seemed to show the want of a guiding hand), until that fatal period of the 1851 Exhibition, when the "Art Journal Illustrated Catalogue" seemed to be sowed broadcast in India, and every abomination in unconstructional and unmeaning forms was given to the inquiring and ready art workers of India as models of the latest and correctest things in European art. The very worst of forms were then wrought out in unsuitable materials for furniture; but the artisans, feeling that something was wrong, tried to compensate for it by over elaboration of detail, which became more and more minute, and finally produced a spongy mass of pierced work with no distinctive character, consisting generally of a fritter of foliage put together without scheme, serving as a background for minute figures of human beings and animal sscattered few and far between, like raisins in a school pudding.

In other parts of India furniture was being manufactured of purely European shape, but at Madras some effort was made to keep to an Oriental style, resulting generally in failure, as the articles of furniture were but models of temple fronts, of terrific weight, and although in a way constructional, yet objects their owners preferred to see in a museum rather than as decorating their own rooms.

The same thing occurred at Ahmedabad, where an intelligent and thoroughly well trained American architect* started a factory for the manufacture of furniture and architectural woodcarving, which he used pretty largely in the decoration of New York mansions. The work produced by him was excellent, but soon some of those persons who are ever on the watch to profit by other people's brain capital started on the same lines, and at recent exhibitions several pieces of furniture, perhaps the most remarkable ever sent from India, have been exhibited, adding to the unfortunate list of the failures which generally result from ignorant interference with ancient landmarks in art. They were models about one-tenth of the full size of the carved fronts of houses at Ahmedabad, utterly useless for any other purpose than to be kept within a glass case and exhibited with wax flowers and pith temples.

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* Mr. Lockwood de Forest.

More recently, well-designed furniture has been produced in the workshops of Mr. Wimbridge at Bombay; also at Messrs. Proctor's, who, at the Paris Exhibition last year, showed furniture as light as Chippendale, but of Hindu-Saracenic style, and—as a lesson to wealthy Indians—upholstered with *mushro* and *himru* satins, far more beautiful as coverings than the gaudy and expensive silk damasks, the "remainders" of European commerce, which are collected and shipped to the Indian market as a last resource.

Probably the best results in furniture, so far as keeping strictly within native lines of construction and decoration is concerned, are the productions of two schools of art, namely, Lahore and Madras, where Mr. Havell, the director, has shown that it is possible to keep within the bounds of Hindu art without imitating the massiveness and grotesqueness of Hindu stone architecture.

For native use, architectural wood-carving is still a very important industry, and I question whether it has in any way deteriorated. It is so important and widespread that I cannot attempt even to give the leading districts of its production, as I should fail to do justice to the subject for want of space. There remains, therefore, only to notice the inlaid furniture of Hoshiapur, in which *shishan*-wood is inlaid with ivory—often with the most graceful and happy effects—in Saracenic style, and the purely Hindu carving of Mysore and Kanara which, for finish, is unequalled in any part of India. The decorations of the latter, unfortunately, are merely transcripts of the designs used in the temples, both wood and stone, and although most exquisite in execution, and often in drawing and composition, the reckless use of labour in their production places them above the reach of ordinary commerce, and the faulty construction of the objects makes them unsuitable for any practical purposes.

Stone-carving belongs principally to the North-West Provinces and Rajputana, and here, again, is an art which cannot in any way be said to have lost ground. All travellers in India know the wonders of the past, the temples at Abu, Abkar's dream in stone at Fathipur Sikui, and the Taj Mahal; but if they doubt that it is possible to emulate these works it is only necessary to visit the modern cities of Khorja and Bulanshar to see that natives, working for themselves, can still design and do all the work they produced in the old time. Then the college buildings at Ajmere, Colonel Jacob's People's Palace at Jeypore, Mant and Chisholm's royal buildings at Baroda, and Chisholm's Government buildings at Madras show how much can be done where Indian and European work together; and we should be thankful for a movement in the right direction in time to save us from the reproach of having destroyed a school of architecture which, if it could not claim to rank amongst the great styles of the world, yet at least had many beautiful features, and was certainly the most suitable to the country and its mixed races.

Last of all, a few words about what probably is the very oldest art of the country, that of the jeweller. Here, again, the spirit of the age is at work, and perhaps with more deadly effect than in other of the Indian arts wherein utility, to some extent, checks extravagance of fashion. If we look upon this art by the light of Hindu custom, where the family hoard was in safest keeping when protected by the vanity of the wearers of the bracelets, earrings, and necklaces, in which their savings were invested, we find some justification for its use by so thrifty a people. Still, in many parts of India, can pieces of modern make be found which rival Roman, Etruscan, or Greek work, both in gold and silver. Nothing can be more beautiful and appropriate than the jewelled work, plain or gemmed, of Travancore, the stamped and filigrain work of Bombay and Cutch, the enamelled gold of Jeypore, and many of the Delhi patterns, both in gemmed and plain work. The peasantry of the Panjab have forms in silver which would compare with any silver work, either pierced or filigrain, in any part of the world, and Cashmere has characteristic designs both in metals and jewels. But everywhere by degrees bad forms are creeping in. The Orissa filigrain shows a style fallen as low as the corresponding work of the Mediterranean; the exaggerated *swami* feature in Madras jewellery is revolting in its vulgarity; the Jeypore enameller is introducing new colours and new shapes, forgetting that it is harder to obtain perfection with complicated elements in form and colour than by means of the old simple tints and a few conventional forms well understood and long tried. The Delhi and Lucknow makers of those humble ornaments (the bangles), forsaking the beautiful patterns which the Hindus have used for tens of centuries, have followed the lead of Bengal, the Province which has always exercised the most destructive influence on art, and, for mere novelty, are now taking to cover their work with knobs of silver cut in facets to represent by glitter the living light of diamonds. This I mention, as these vulgarly glittering bangles have found great favour with our people at home; and, therefore, exert a strong influence in turn on native work, and I wish to add that these facet-cut ornaments err, not only as being an attempt to represent a totally different and superior material, but because of the practical reason that their glittering appearance depends upon newness, and a little wear leaves only the mean effect of a damaged crystal. The ancient bangles were copies in gold and silver of native flowers and fruits, used for personal decoration in the early pastoral days of Hindu civilisation; copies, but in a superior material, and in that superiority was their merit. A prince might be proud of carrying a golden rose, but who would own to wearing a tin diamond.

In conclusion, I am forced to repeat that a very great responsibility rests upon ourselves for the part we have taken in destroying the ornamental handicrafts of India. Nor is this much lessened by the costly efforts in recent years to save ourselves from this reproach. Whilst handicrafts are perishing before our eyes, which in many instances are all that is left to us of the great arts of antiquity, we are squandering large sums on antiquarian historical research in India of little practical value. We have spent over £30,000 in useless copies of the cave paintings at Ajanta, and yet we are allowing the few craftsmen to die out who possess the secrets of some of the noblest arts of antiquity, such as true fresco painting; not the half-wrought work of the middle ages, but the marble-like, hard, silicious work which we find at Pompeii, and still practised in India.

The reason of all the anarchy and destruction we have introduced into the artistic productions of India is our failure to appreciate the great value of workshop lore and rule-of-thumb trade secrets, which all the colleges and schools in the world can never replace when once lost; and, worst fault of all, our habit of considering art questions as mere matters of individual taste, and not as appertaining to a science as positive as any other, and only more difficult owing to its vastness, and the want of common agreement as to its terms.

It is to the preservation of the old workshop traditions that we should devote our energies if we are in earnsst in all our talk about preserving the industrial arts of India. It is this workshop life of master and apprentice, as old as when Jacob served Laban for seven years, that brought these arts into existence, and only these conditions will in any country maintain true art in vigorous life. Great craftsmen like William Morris and Herkomer have realised that this is the only way of salvation in the ornamental arts, and if there is to be any future for our now middleman crushed arts, it will come from work produced under such happy conditions as exist at Merton and Bushey.

Last of all, the Indian Government cannot clear itself from blame by spending annually a large sum of money on schools of art, museums, and archæological work, when it neglects every opportunity for giving effect to the repeated statements of its desire to encourage native art. When presents are exchanged with Indian and other Oriental princes, the best craftsmen of the country should be employed to prepare the gifts, and a fashion set to the princes and wealthy, who would gladly follow such a thoroughly Oriental and congenial example.

The newly-built palace of the Viceroy at Simla afforded such an opportunity, but instead of illustrating the art resources of the country, even from the School of Art point of view, and overlooking the fact that the fastidious Rothschilds of Paris, and Vanderbilts of New York were obtaining furniture and decorations from Bombay, the Viceroy in Council handed over the decorations, upholstery, and furniture to an advertising firm in the Tottenham-court-road, London. It is not to be wondered, therefore, that with this example, the Gaikwar of Baroda followed suit, and, flying a little higher, furnished his palace from the Faubourg St. Antoine, at Paris.

There is only one remark I wish to add, and that especially for any Indian gentleman who may be present. I most sincerely believe that as the rulers of India we have ever had but one idea, and that the amelioration of Indian peoples; and if, in carrying out this idea, we have neglected or injured native Indian art, it has been from the same mistaken good motives which led us, during the same ill-starred period, to neglect and injure our own indigenous English art. If we introduced a travesty of classical architecture in the last century at Calcutta, and have since filled the palaces of rajahs with libels on French furniture and decoration, we were doing the same at home; and if, some years back, the museums of Calcutta and Madras contained English art pottery, Italian stone carvings, and pictures, whilst Indian art works were conspicuous by their absence, we in England, to this day, show just as little respect in our national museums for English art, taking no trouble to systematically collect examples to illustrate its history, although we pay the highest price of any of the nations of the world for anything in the shape of a foreign "curio."

DISCUSSION.

The CHAIRMAN said:—On this occasion I must depart from my usual practice of reserving any remarks I may have to make for the close of the discussion, as it is as well, perhaps, to at once clearly state what are the chief points of contention raised by Mr. Clarke. Of course, the paper, in its whole purpose, directly traverses the main arguments of my handbooks on the "British Indian Section of the Paris Universal Exhibition of 1878," and on the "Industrial Arts of India," that the arts of India are essentially Hindu in character, and that the influence of the Schools of Art teaching on them is most devoutly to be deprecated. In regard to the former argument, I over and over again state that many elements, some traceable and others not, have contributed towards the development of the decorative arts of India, and that foreign styles and forms are always being introduced into the country, where, owing to the remarkable mimetic genius of the people, they are at once imitated with the greatest avidity. But I contend, and I hold have demonstrated, that owing to the immemorial training of the Hindu people in the arts based on their all-pervading religious life, every style and form of decoration, once naturalised in India, comes at last to be more or less assimilated to the one universal generic type impressed on them by the intellectual superiority of the race of Brahminical Hindus, and which distinguishes their arts in every species and variety as still characteristically Hindu arts. Again, I distinctly state that so many new handicrafts have been introduced into India by foreign conquerors—Persians, Scythians, Mongols—that it would seem as if the Hindus had really no arts of their own; but I add also that nothing could be more misleading than such a superficial conclusion. We may accept all that Mr. Clarke has stated as to the foreign sources of some of the Indian handicrafts enumerated by him; I have admitted it all in my two handbooks. But take, on the other hand, the overwhelming testimony furnished by the Code of Manu, the Râmâyana and Mahabhârata, the "Silpashastra," the Ajanta Caves, and the antiquity of the Indian trade guilds. The Code of Manu proves that the present social and industrial organisation of Hindu society has been in existence from at least 500 years B.C. The present text of the Code is of far later date than that, but it undoubtedly refers back to at least 500, and some would insist, 1000 B.C. The Râmâyana and Mahabhârata, which are variously placed from B.C. 300 to A.D. 300, prove that about the Christian era in northern India, most of the sumptuary arts of India of the present day already flourished in the highest perfection. As to the "Silpashastras," there is no regular canon of these writings; anything written by anybody on handicrafts is, in Hindu eyes, a *silpashastra*. But such independent monographs or handbooks are to found in Sanskrit dating from the 1st century. The very earliest of them is in the India-office, and give the minutest details for the construction and decoration of the Hindu temples. Then consider the significance of the unbroken continuity of trade guilds in India from the establishment of Buddhism, which grew out of the internationalisation of Hinduism through the great international trade organised in the Indian ocean by Psameetichus I. and Nebuchadnezzar the Great, in the 7th and 6th centuries B.C. Arrian's "Periplus" has preserved to us every detail of that trade, and the positive demonstration that it was made up of essentially the same sumptuary articles for the manufacture of which India is still distinguished. The graphic evidence of this is to be partially found in the Ajanta Cave paintings. They represent the life not of northern India but of the still savage hill people of Western India in the first century of the Christian era, who we see in these frescoes wearing striped cottons identical with those still used by the wild tribes of Central India; while in one of the scenes there is represented a carpet apparently of wool, and ornamented with sprigs of flowers, very much in the style of the so-called Baluchistan rugs of to-day. Can it be believed that all this traditional training in the manufacture of textiles, in decorative carving, and metal work, going back to the earliest date of the consolidation Aryan ascendency in India, has not always profoundly modified every foreign element of art brought within its influence. Therefore, speaking of the Code of Manu, I say that it has secured to the village system of India a permanent endowment of the class of hereditary artisans, who of themselves constitute a vast population, and the mere touch of their fingers, trained for 3,000 years to the same manipulations, is sufficient in the course of time to transform whatever foreign work is placed for imitation in their hands into something rich and strange, and characteristically Indian. Now, passing to the Schools of Art, let me say at once that I have always most scrupulously refrained from using my official position for furthering the views I hold as to the evil influence exerted by them on the indigenous handicrafts of India. I have been content to hold them as "pious opinions," particularly since Mr. Kipling, Mr. Griffiths, and Mr. Havell are all three now sincerely striving to adapt their teaching to the principles and traditionary methods of the native arts practised around them. But after what Mr. Clarke has said, I must take advantage of the present altogether unofficial opportunity to point out how remarkably the Government Schools of Art at Lahore, Bombay, Madras, and Calcutta have in recent years become gradually transformed into State factories. This is particularly the case at Lahore and Bombay. The productions of the Indian Schools of Art were mere curiosities at the Paris Universal Exhibition of 1867. In the International Exhibition held there in 1878 they still occupied a very subordinate position; but in the Colonial and Indian Exhibition held here in London in 1886, they overwhelmed the Indian section with their ubiquitous presence. They were as prominent there as the Indian jail carpets had been at the French Exhibitions of 1867 and 1878. This has certainly had an injurious effect on the demand for Indian art objects which had been growing up in Europe ever since 1878. Do what the Schools of Art may under enlightened direction, their influence cannot but be to weaken, if not destroy, the strong local and traditionary character of the truly vernacular handicraft work of India. The antique quality of Indian art is the very characteristic that makes it attractive to the taste of Europe, and to attempt to put modern invention into it is to destroy its distinctive mark and special market in Europe. Owing also to the Schools of Art having gradually become large Government factories of "Sidonia wares," increasing difficulties are arising in providing them with assistant teachers. Art teachers can still readily be obtained for such salaries as are sanctioned by the Government of India for their Schools of Art; but what these institutions under their recent development require for their working management are men of the class of the "foremen" of such art factories as the Messrs. Doulton's at Lambeth, and the Messrs. Elkington's in Birmingham. The Science and Art Department cannot supply that demand, and men of the sort are not to be obtained anywhere under £1,000 a year. Such men beside their pay receive a commission, which, in a case within my personal knowledge, amounts sometimes to £12,000 a year. For my own part I would not have art taught at all in India. The great need of the artisan class in India is technical education, particularly in carpentry, joinery, and engineering. They need it to put their art wares on a sound mercantile basis; and we owe it to them to provide this education for them; and I hope that gradually the Government will see its way to converting all the Indian Schools of Art into technical schools. A great step has been taken in this direction in Bombay, under the initiative of Lord Reay, who deserves the highest praise for it. The deficiency of Orientals, from Morocco to Southern India, in technical skill is very remarkable, for they have always betrayed it over the whole of the area indicated. While writing these remarks I quite accidentally came across, in the Mostellaria of Plautus III., 2. [Bohn's Translation], the criticism made by one of the characters on a piece of artistic carpentry:—"It is no foreign *pulse eating* artisan did this work—*don't you see the joints in this door* . . . . . . Look *how close they sleep* together." The allusion is to the artisans of Carthage, who were excellent carvers, but bad joiners. None of the Orientals appear to have energy enough for good joinery, until you come to the flesh-eating people of China and Japan, who are the most exact joiners in the world. But the evil we are fostering in India, through the action of the Schools of Art affects far wider and more serious interests than those of Indian art. The damage done to the native weavers by the competition of the Indian Government jails in the manufacture of carpets was not at all exaggerated in my little "Handbook to the British Indian Section of the Paris Universal Exhibition of 1878." The distress caused in the Madras Presidency in particular was very general; and the facts supplied to me by the late Sir Walter Elliot were of the most pitiable description, and so injurious to the British name that I could not publish them in detail, and therefore confined myself to vague generalities. But the ultimate effect of the growing competition of the Schools of Art will, unless checked, be far more fatal, for its operation on the artisan classes of India will be almost universal. The Schools of Art are gradually securing a monopoly, so far as the European demand is concerned, of all the minor handicraft manufactures of India; and just as now it is useless for any but enthusiastic importers to buy their Indian carpets from anyone but the superintendent of a Government jail, so presently it will become necessary to place orders for the smaller Indian art wares required in Europe exclusively with the Schools of Art. Mr. Watson, of Messrs. Procter and Co., tells me that already he is being driven to take this course. Such an economic change, over so wide an area, must lead to very grave consequences. Rome was ruined by the substitution of slave labour and State labour (which grew out of slave labour) for the free labour of the people of Italy. It was not only agriculture that suffered through the development of this system, but every class of domestic industry. The prisoners taken in the Asiatic wars of the empire were sold as slaves, through the dealers who accompanied the Roman armies, not only to the country gentry as agriculturists, but to the wealthy townsfolk as artisans,—weavers, jewellers, embroiderers, armourers, blacksmiths, and shoemakers,—and even as writers and readers. Inevitably the State itself became the largest employer of this slave labour, and at last everything required for the use of the State was done by slave labour, the slave being "sweated" until he ceased to breathe. Free labour thus perished throughout Italy, and henceforward all labour throughout Europe remained under the stigma attaching to it from this connection with slavery down to the end of the Middle Ages; and the sort of slur that still attaches to the profession of medicine may be traced back to days when the wealthy contractors of Rome bred up a promising slave as a surgeon or physician. For centuries all Europe suffered from the economical revolution thus wrought in every department of intellectual development. These slaves were Asiatics, without any power of invention or any instinct for progress; and from the time their employment in Italy became general, Western civilisation began to droop and decay. It was as a consequence of their employing Asiatic readers and writers, that the Romans failed to develop a system of shorthand numerals, and a cursive alphabet, and true script. They never, in fact, got beyond the simple cypher-writing* employed by Julius Cæsar, which consisted in substituting for each true phonetic letter of a Latin word the fourth letter from it in alphabetical order. Of course, it is deeply interesting to know that through the introduction of slave artisans into Italy the inventive and progressive type impressed on the arts, originally received from Asia, by Greece, was greatly effaced, and their Asiatic type revived, and stereotyped down to the close of the Middle Ages, and indeed to this day, in the ecclesiastical art of Christendom; but the interest of this circumstance to the curious and learned is not a sufficient set-off to the general detriment done to Western civilisation.

Mr. SPARKES said there seemed to be a somewhat melancholy tone running through the paper, to the effect that whereas 100 years ago or more there was true art in India, now, under the stimulus of the middleman and the demands of modern trade, it was going to decay. That did not strike him as being anything new; he took it that the best art had always been produced under the stimulus of a beneficent tyranny of some form or other, either social, ecclesiastical, or individual, and that as the arts came to be demanded by the million, they appealed to such a large constituency that good taste, which was always a rare gift, ceased to apply. In all probability, therefore, this decadence would be found to proceed at the same rate at which demands were made on the modern Hindu art producer. He was obliged, as people were in England, to consult the tastes of the buyers, who, from his point of view, were a great uneducated mass who did not appreciate a good thing when they saw it. The manufacturer might plead that he had to earn his living, and, with a few qualms of conscience, he had to meet the demand. We were thus in a vicious circle; the purchaser was not sufficiently educated to demand a good thing. Mr. Herkomer was one of the beneficent tyrants to whom he had alluded; he did not produce articles for sale, and was not going to affect the arts of this country. He was simply doing what was done in old times. The old nabob had the best workmen he could find, and paid what was asked for the work. Now a man had to work against time for a very low price, and the result was that the purchaser got what he paid for.

The CHAIRMAN remarked that the tyrants who encouraged the arts were not always beneficent.

Mr. VINCENT ROBINSON said he sympathised with the views expressed by the Chairman in some respects. It was very plain, with regard to the industry with which he had been for some years associated, that the prediction which he ventured to utter some years ago was actually coming true, and that the art industry of making carpets in India was dead. People might order carpets, but an art carpet could not now be produced in India. Whether it would be possible to stop the decadence of other arts he could not say; he feared it would not; but the only way would be to limit the influence of the Schools of Art, which certainly did not seem to be needed there. What the Chairman said about workshop training was of the greatest importance. Drawing on paper was of no use to people who worked in metal or printed on cotton, and for a carpet manufacturer to be taught drawing on paper was absolute childishness; he was referring of course to the manufacture of Indian carpets.

Mr. HUNTER DONALDSON thought that if the action of the Schools of Art in India were confined to the selection of admittedly superior examples of all those works to which Mr. Purdon Clarke had referred, and if a careful selection were made of teachers, whose functions should be simply to point out the principles and characteristics which distinguished those beautiful works of art, great benefit must result. It had been within his experience that a vast deal of feeling had been altogether misdirected in India, and the result had been the production of works in wood which should have been in stone and *viceversa*. The Government should seek to obtain from disinguished Indians, who had been so liberal in other directions, examples of the best works existing, in illustration of the various arts, and it should also encourage teachers who would point out the distinguishing characteristics of those arts and the points in which they were peculiar and to be imitated. He could not agree in the statement that good taste and vulgarity were both fairly meted out, irrespective of position or race, because he thought the Indian arts proved that there was a singular sensibility of hand, a remarkable dexterity, and a wonderful sense of propriety of ornament to the particular object or surface to be covered, to be found mainly in India, though the same thing had been illustrated to a remarkable degree in Japan. No Englishman or Frenchman could attempt the wonderful achievements which that art exhibited; there was a co-ordination between certain mental qualities and manual dexterity which were altogether unknown to the European, and in India there was very much the same thing.

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* Cypher writing seems always to have been practised by Asiatics, long before regular writing. That is, they communicated secretly by signs, even before a settled syllabary or an alphabet was developed among them. And the *semata lugria*, or the "lugubrious signs" borne by Bellerophon to Prœtus (Homer's Iliad VI.) are supposed to refer to the practice.

Mr. LAZENBY LIBERTY said he had been much relieved to hear from the Chairman that, after all, there was a real Hindu spirit at the bottom of Indian art, for the paper seemed to attribute it entirely to a Saracenic origin. With regard to the decorative character of Indian art in comparison with the Japanese, much as he admired the latter, he could not help feeling that there was something stronger and firmer in the work of India. Mr. Clarke was rather hard on the brilliant bangles, which he did not think were intended to imitate diamonds; and he did not think the comparison between a golden rose and a tin diamond was quite to the point.

Mr. W. MARTIN WOOD said it was exceedingly difficult to deal with such an extended subject as Mr. Clarke had brought before them, but the paper had the special merit of giving within a small compass those guiding principles which were so much required in approaching this subject. The Chairman had enlarged the scope of the paper, and seemed to dispose of the contention that there was no indigenous art in India, but he had to some extent harmonized Mr. Clarke's more special views with that which had been also referred to by other speakers, as to the aptitude and absorbing and adaptive qualities of the Indian artisan. This perhaps showed itself more in manipulation than in design, but there it was. He wished something could be done to arrest the decay of the Indian art handicrafts, and he was glad to hear that there were some regenerative influences at work. The question was how they could be adjusted. Almost everyone condemned the Schools of Art, and the Chairman suggested that they should be replaced by technical schools, for giving training especially in these arts of carpentry, joinery, and making things with right angles, which Hindus were so deficient in. It was very satisfactory to know that there was an appreciation by English artists of the essential qualities of Indian art, although it was rather difficult to define them. He might refer to an incipient effort which was made some time ago to assist Indian art, which yet waited further development. The inspiration was given by one of the best water colour artists of the day, Mr. Frederick Shields, who wrote as follows:—"Meeting with some Indian students sojourning in London, and expressing admiration of the decorative arts of India, he was surprised to find his hearers filled with astonished gratification. They had never heard, they said, such sentiments from the mouth of an Englishman, either in India or England. And they sadly averred that the producers of the art of India are rapidly losing all confidence in their native powers of design under the blighting indifference or contempt of the majority of the representatives of English taste. They were quite unaware that among these there are found some who not only rightly estimate the glory and preciousness of the glowing garden of Indian design, but who have also long, and preseveringly, and zealously exerted themselves for its preservation. The material prosperity and superior power of England have, moreover, a tendency to compel from the people of India a deference to that assumption of more cultivated taste which is tacitly claimed by the establishment in their cities of Schools of Art, branching from South Kensington, for their instruction in the dull and sterile methods of European ornamental composition. It is evident that under these influences, both negative and positive, the extinction of India's virile fertility of living design must rapidly arrive, and that this end will be precipitated by the fraudulent reproduction by German and English manufacturers of their most beautiful designs, so underselling with mechanically woven imitation the playfully varied and entrancing originals. In view of these things, it seems the duty and privilege of all who have drawn in delight from the art of India, and who rightly value it as a priceless and inimitable thing, and who consider that its loss would be a loss beyond all repair, alike to India herself and to the world, to consider what may be advised to counteract the influences aforesaid, and reinspirit the art craftsmen of India with just confidence in the gifts peculiarly bestowed on them by the Great Giver, as well as to arouse the taste of our own people to a discernment of the original's beauty, compared with the false imitations." The question was, how could that be applied. Some who met together last year thought a Society might be formed—and the approval of Sir James Linton and several other artists was obtained—with the simple object of reassuring the native craftsmen of India in the way Mr. Shields spoke of, but the difficulty would be to get at them; that, however, was not insurmountable, and thus they might be encouraged to persevere.

Mr. GOUR said he had listened to the paper with much interest, but regretted to say that it was based on a misconception. One gentleman had said that all fine arts were the result of a beneficent tyranny, and that seemed also a misconception. His idea was that the fine arts were more due to the tyranny of instinct and of genius, and some of the finest works in India, as well as in Greece and Rome, whether in sculpture or other arts, were executed simply for the sake of the pleasure it gave the workmen, in the same way as the great poets wrote poetry, not so much to make money as for the pleasure it gave them. He believed that was the case with his own countrymen with regard to different kinds of art, they took an interest in art originally for the sake of beauty, and the desire to produce it objectively. Some of the finest structures, the Taj Mahal for instance, were planned by a single man. It was recorded in the legends that an anchorite came to the king and said he would construct a building of a certain kind, and laid down the plan before him exactly in the way in which it was finally constructed. Allusion had been made to the want of support on the part of the Government, but he was not sure whether the Government were really in fault. Ever since the Mutiny, and the consolidation of English rule, new industries had developed in India, coal mines had been thrown open, and railways and telegraphs constructed, and if the Government of India, now in this primitive stage of civilisation, were to devote any of its resources towards the development of luxuries — for fine arts must always be luxuries— instead of further developing the construction of railways and telegraphs, and the connection of the various parts of the country, which were now separated by ranges of mountains, it was questionable whether it would be really a benefit to the people. With regard to Japanese art, it was not, as a whole, serious; it was conceived in a totally different spirit from that of India. From the art of a country you might learn the national characteristics, and the Japanese, as a whole, as Sir Edwin Arnold had described, never took life seriously. Indian art was entirely different; not only was there no resemblance between the two, but there was a positive contrariety. Indian people, as a whole, took art seriously; though some of their figures might be grotesque, they were all made for religious purposes, and, naturally, such a thing could not be produced with levity. The Chairman had intimated that Indian art had not borrowed from Saracenic or Persian sources, but although that was a little flattering to the Indian people, it could not be denied that if Indian art were examined closely, it would be found that there were traces of borrowing from many sources; it was, in fact, partly original and partly borrowed.

Surgeon-Major INCE, as one who had spent two seasons in Cashmere, had had an opportunity of studying the arts as carried out there in their purity, and as superintendent of a jail he had seen the production of those spurious articles which were called Indian carpets. One was the height of art, the other the zero. The undoubted superiority of Hindoos in certain classes of work was the result of the hereditary principle; that was the whole secret of it. These people had been brought up, generation after generation, to the same trades, according to their different castes, and you might see jewellers, almost infants, performing skilful operations which the oldest members of the Goldsmiths' Company would find it difficult to imitate. The English were only just emerging from a state of comparative barbarism, while the Indian and Chinese civilisations were far more ancient, and their superiority in handicraft work therefore was immense.

The motion that a hearty vote of thanks be awarded to Mr. Purdon Clarke having been put by the Chairman and carried,

Mr. CLARKE, in acknowledging the vote, made the following remarks:—First of all I wish to disclaim any intention of traversing in any way the main arguments of Sir George Birdwood's Handbooks, either of the British Indian Section of the Paris Exhibition of 1878 or the "Industrial Arts of India," published by the South Kensington Museum; my aim having been rather to supplement them by following out certain lines in the history of the introduction and development of the arts of India as shown in these works, particularly of those arts of which I have had the advantage of previous knowledge in the countries of their origin. It is probable that I have not sufficiently mentioned the indigenous Hindoo arts, but the reason, I think, is given at the opening of my paper, where I say that "the arts of India in which we are most interested are, like ourselves, aliens to the country," and through my paper I have kept to these particular arts which, from some cause I do not at present attempt to explain, prove themselves to be of the greatest interest to us. There is not the slightest doubt about the glazed pottery, which came in through Scinde, the whole system of the production of which is entirely different from Hindoo potting, from the throwing wheel to the kiln. Then the printed cottons, which have been exported within recent historical times, have all been of Mohammedan manufacture and design, the Hindoo productions being entirely unsuitable for any European purpose. I may here mention that the stamping of patterns on cotton was not only known in most of the countries within the influence of China, where the art most probably originated, but was practised both by direct printing and the use of reverses in America before the European invasion. A very fine collection of ancient American printed cottons covered with Mexican designs has been exhibited in the Ethnological Museum at Paris for the past ten years. With respect to carpets, I can only affirm that they are of Saracenic origin, as they have no place in the domestic economy of Hindoo life, and it is most probable that the solitary carpet depicted in the Ajanta Cave paintings is, like the Persian drinking vessels in the picture of the reception of the Persian Ambassador, the representation of a royal present from a foreign king. I cannot quite agree with the Chairman with respect to the local value of the Ajanta Cave paintings, in their only representing the life not of Northern India but of a still savage hill people of Western India, whilst it is inferred that a very much higher civilization existed in other parts of the country. The proofs of this civilization, I fear, rest principally on writings which are about as accurate as the "Morte d'Arthur," an unfortunate book which has led poets and painters astray for five hundred years, by describing a condition of society which did not exist until a thousand years after the date ascribed to it, the leading events being based on chivalry, the result of the Crusades, and the paraphernalia of 13th century armour, without which none of the incidents could have come about. With respect to the Schools of Art and technical schools, I fear that they are necessary evils, but they should not be allowed to interfere with the old systems by which art was taught in the workshop, and exactly the right amount of technical knowledge perfected which the several trades required for their own use. If Indian artisans do not know how to build European furniture, it is possible that it is more because they pay greater attention to the decorative than the constructive side, and in this they are not alone. Anyone who knows the fine pieces of furniture of the Middle Ages, which now fetch such fabulous sums, cannot fail to have noticed that fine joints, close-fitting doors, and easy sliding drawers seem to be about the last things thought of by their makers; and that, as furniture became more perfect in its construction and finish, it declined in the vigour of its art. Mr. Donaldson's exception to my statement that good taste and vulgarity are fairly meted out irrespective of position and race, I think would be withdrawn if he had had the same opportunity of studying not only India but other countries celebrated for the artistic qualities of the people. We are too apt to jump at conclusions from knowing only one side, and, only seeing the rare and beautiful objects brought from India, we do not take into account that which is left behind. Whilst the Hindoo people—and, for that, the Oriental and other nations surrounding the Mediterranean—had but the old harmonious scale of dyes, they were attributed undeserved credit in a measure for the harmony and the beauty of the colours in their stuffs. But the avidity with which they seized on every abomination in aniline, the preference shown for the red and black Rob Roy tartan in shawls both in India and even in artistic Italy, and the general mixing of scarlet, emerald green, mauve, and chrome yellow, which has been noticed so much by travellers in the Mediterranean and the far East of recent years, all goes to prove that good taste is a matter of education, and that the untrained eye, like the untrained ear, prefers contrast or discord to harmony. I entirely agree with Mr. Donaldson in his remarks on Japanese art, which I take to be one of the exceptions to prove my rule, these people having undoubtedly been blessed with more than their average share of good taste. I am sorry that Mr. Martin Wood misunderstood me; I never contended that there was no indigenous art in India. I feel very much in harmony with the rest of his remarks, and know how zealously he has worked for years past with the one purpose of preserving all the arts of the country. I must, however, take exception to a statement in his quotation of a letter from Mr. Frederick Shields, this letter having been very widely circulated and, I consider, of a mischievous character. These Indian students who were surprised to hear his praise of Indian art must have been making fun of him. They said they had never heard such sentiments from the mouth of an Englishman either in England or India, and spoke of the blighting indifference or contempt of the majority of the representatives of English taste. The true position of affairs is exactly the contrary. The prospects of Indian art have been blighted by undue praise, praise lavished upon everything—good, bad, or indifferent—so long as it was Indian; and I can confidently assert that, having during the past twelve years conversed with some hundreds of people on the subject of Indian art, I have always found them ready to accept everything coming from India as an artistic production, even though sometimes, in their eyes, it appeared to be wanting in artistic qualities; the exceptions having been those who, like myself, had studied the universal history and growth of ornamental art, and, whilst giving Indian art a good place amongst the arts of the world, do not place it in the first rank, excepting for its eminent suitability to its country and people. We ought all to be grateful to Mr. Gour for taking the trouble to examine the question from an Indian point of view; but I fear that his remarks are more the result of abstract speculation than study of the history and technology of the subject. He first says that the paper is based on a misconception, but does not point out the misconception he alludes to. Then, contradicting Mr. Sparkes—who very rightly stated the fine arts were the result of beneficent tyranny in many cases—he goes on to state that the fine arts are more due to the tyranny of instinct and of genius, and that some of the finest works in India, as well as Greece and Rome, whether in sculpture or other arts, were executed simply for the sake of the pleasure it gave the workmen, in the same way as the modern great poets write poetry—not so much to make money as for the pleasure it gives them. From my knowledge of the artistic temperament, where it is so strong in the individual, that it exercises a tyranny over his actions, I am positive that in no case would any such men ever complete the great works alluded to by Mr. Gour. It was the beneficent tyranny of princes and employers which forced the artists and poets from their dreamland of sketches into the solid works which we admire in their perfected state. Mr. Gour gives us an example of the kind of history upon which many claims of India to a high civilisation at remote periods rests, but in this case we are fortunate in being able to test his accuracy. The Taj Mahal, he states, was planned by a single man, and it is recorded in their legends that an anchorite came to the king and said he would construct a building of a certain kind, and laid down a plan before him exactly in the way in which it was finally constructed. Now this Taj Mahal differs very little from Humaion's tomb, a building a hundred years older, and both belong to a class of building of which there are many hundreds of examples, starting at a fairly remote antiquity, and showing a development from a single-domed tomb until finally lost in the monstrosity at Jaunagur. With Mr. Gour's remarks respecting the inability of the Government to find money for art whilst it has the more important question of mines and railways to attend to, I must refer him to Sir George Birdwood's books, especially the "Handbook to the Exhibition of 1878," in which he will see that India once had a great export trade in works of art, and if this could be revived there would be plenty of money to make its railways and dig its mines. Lastly, a few words upon Surgeon-Major Ince's remark that the English are only just emerging from a comparative state of barbarism, whilst Indian and Chinese civilisations are far more ancient. I think this is an opportunity to say that if we would leave ancient records alone, and consider only the evidence of existing monuments, we in England could show, date for date, about as good art examples as India, and probably China. The very few Indian monuments before the 1st century only differ from Stonehenge in surface decoration, which owes more to Assyrian, Greek, and Chinese influence than to any indigenous art. I doubt whether any of the stone carvings of India can be said to excel artistically, in delicacy and appropriateness, the tracery in the roof of Henry VII.'s Chapel in Westminster Abbey; nor is there anything from India that could stand against our college and corporation plate, or, in wood-carving, equal to the open work on a violin given to Queen Elizabeth by Dudley, Earl of Leicester. Surgeon-Major Ince rightly explains the secret of the perfection of Indian workmanship, in attributing it to the hereditary system, nor could it be otherwise that great perfection should be obtained when, generation after generation, in certain trades for several thousand years, the same forms were fashioned without any change. My difficulty, in speaking of modern Indian art manufacturers, is that of making people understand that fine workmanship and elaborate design—however lavishly used—do not entitle objects to be classed high as works of art unless they possess also the higher qualities of appropriateness and beauty of form, without which the labour of their makers is in vain.

SEVENTEENTH ORDINARY MEETING.

Wednesday, April 16th, 1890; Dr. GARNETT, Keeper of the Printed Books at the British Museum, in the chair.

The following candidates were proposed for election as members of the Society:—

Barry, James H., 110, Cannon-street, E.C.
Blakely, William, Vernon, Bournemouth West.
Browne, Andrew, 13, Fenchurch-avenue, E.C.
Burnett, Robert, 47, Carden-place, Aberdeen.
Denny, Archibald, Leven Ship-yard, Dumbarton, N.B.
Herschell, Lord, 46, Grosvenor-gardens, S.W.
Joseph, Major Hymen Aron, Rutland-house, 45, Aberdeen-park, Highbury; and Junior Carlton Club, S.W.
Lindo, Gabriel, 36, Orsett-terrace, Hyde-park, W.
Storr, Walter W., 3, Victory-terrace, Redcar.
Wilson, Henry J., M.P., Osgathorpe-hills, Pitsmoor, Sheffield.

The following candidates were balloted for and duly elected members of the Society:—

Barrett, George Wilson, 9, Albany-court-yard, Piccadilly, W.
Brounlie, Charles de Bels, Gothic-house, Lower-road, Richmond, Surrey.
Congdon, John, 135, New Bond-street, W.
Lanham, Robert, Forest-house, Chingford, Essex.
Lansbury, Henry John, Town-hall, Bromley, Kent.
Mayne, Charles, Shanghai, China.
Pepper, Joseph E., Clarence Iron and Steel Works, Leeds.
Roberts, Thomas, 13, Corve-street, Ludlow.
Smith, William Howard Seth, 46, Lincoln's-inn-fields, W.C.
Swan, Joseph George, Upsall-hall, near Middlesbrough.
Tolmie, Andrew Denny, 166, Buchanan-street, Glasgow.
Wilson, T. Hay, 10, St. Bride-street, E.C., and Crawcrook, Chingford, Essex.
Worssam, Henry John, Wenlock-road, City-road, N.

The paper read was—

OLD AND NEW FASHIONS IN TYPOGRAPHY.

By TALBOT B. REED.

My object to-night is not to cover the whole ground comprehended by my title. I do not propose to criticise styles or methods of printing. Nor do I desire to venture on the vast field of controversy involved in an examination of what are termed "fancy" types. That subject is a fair one for discussion, and before quite dismissing it I may remind you that till the beginning of the present century such a thing as ornamental type was unknown. Who was the delinquent to whom first occurred the idea of decorating the ordinary form of the alphabet it would be hard to say. Beyond initial letters of a florid kind (usually cut on wood) and vignettes and *fleurons*, the old typographers never strayed beyond the threefold limits of the Roman, the Italic, and the Black letter. Now and then, abroad, in the 18th century, we meet with attempts to be fanciful, chiefly on German and French title pages, or else in eccentric variations of the form of the German character. But England retained her innocence till the early years of the present century, "at which period," to quote the almost pathetic protest of a type founder of the day, "a rude, pernicious, and most unclassical innovating system was commenced, by the introduction of fancy letters of various anomalous forms, with names as appropriate—disgraceful to a profession once held sacred. . ." The innovation was begun cautiously, taking the form chiefly of the addition of a shaded line outside the solid line of the Roman form. Then the solid lines themselves were shaded or beaded, or it was sought to give the letter the appearance of being sunk in a black ground or thrown up in relief on a shaded surface. Then the form of the letter, in imitation of the copper-plate designs of the period, began to be obscured in a profusion of flourish.

When once it was discovered that the traditional form of the alphabet was not sacred, the passion for "fancy" grew in geometrical ratio. Types appeared leaning this way and that, flowery and stringy, skeleton and fat, round and square. The venerable Black letter was tricked up in modern dress, Italic was sloped off its feet, the Roman alphabet was worried into one contortion after another, until it became almost a merit that the original shape was barely recognisable.

I am not describing a thing of the past. Herod is out-heroded every week in some new fancy which calls itself a letter, and which, in response to a voracious demand, pours into our market, either from native foundries or from the more versatile and supple contortionists of America and Germany. I do not deny that many of our modern fancy letters are graceful, that some are in good taste, that some have a certain beauty; nor am I bold enough to suggest that, at this time of day, they can be dispensed with. But I admit to some misgivings at the lengths to which the craze is carrying us, and the almost total abandonment of traditional models which it involves.

As artists, the printer and the letter cutter are responsible to their generation. We live in the midst of a violent reactionary movement against dullness and conventionalism of all kinds. The artist has his three courses. He may sell himself slave to his public, and go wherever he is driven. He may set himself stubbornly to stem the torrent and fall a martyr to his conservatism; or he may strive honestly to control, even while following, the popular movement, and with his clearer artistic knowledge to direct it along lines of moderation and good taste.

My object to night, however, is not to deal with this matter, important and interesting as it is. The fashions to which I wish to call your attention are those belonging to the Roman character in typography, that is to say, to the type in which books are printed. I propose to take a brief historical survey of the changes through which the character has passed in the hands of various artists, and of those forms of it which at different times have competed for the distinction of realising the perfect model.

I must remind you at the outset that the perfect model of a letter is altogether imaginary and arbitrary. There is a definite model for the human form. The painter, the sculptor, the architect, have their models in nature. But the man who sets himself to make an alphabet has no copy but that left him by former artists. He knows that the symbol which denotes the sound I must be perpendicular, and that which denotes the sound O must be round. But what should be the height of the I in proportion to its width, how the extremities of the stroke should be finished, on what particular arcs and parallels his O is to be erected—on all, that is, which pertains to the *fashion* of his letter—he has no absolute standard. His own eye must furnish the criterion. If the work of those who have gone before satisfies that criterion, he copies it. If it comes short, he corrects it.

What, then, is this criterion? It consists, I venture to think, primarily in the legibility of the character, and secondly in its beauty. It may be urged that the two are inseparable, and I am prepared to admit that, as a rule, the truest beauty in art is that which suggests utility. But it is possible for the two to exist without one another. A boot, for instance, may be beautiful in shape and finish, but unless it fit the wearer it is of little worth. An arrangement of lines and curves and angles may be beautiful in itself, but unless it suggest a form it is valueless. And the more clearly and definitely it suggests that form the more we admire it. Type that is not legible, and in the case of books and newspapers easily legible, however elegant its lines, however delicate its execution, is not good type. So that the artist of letters finds that his first test of an excellent letter is its legibility, and the second—which may easily be a consequence of the first—its grace and beauty.

When we inquire what constitutes legibility in type, we are confronted with numerous interesting speculations and theories. Artists, mathematicians, architects, and doctors have, in turn, tried to lay down rules on the subject. Geoffroy Tory, the Parisian printer, sought to derive the capital letters from the goddess IO, the two letters of whose name furnished the perpendicular and the circle from which every letter was to be constructed to measurements proportioned to the form of the human body and visage. Fantastic as the theory was, Tory's rules, in the master hands of his disciple Garamond, produced, as we shall see, one of the finest models of type in Europe. Albert Dürer made a serious effort to bring the alphabet under rule and compass; but his proportions were better suited to the sculptor than the typographer. Nor did the ingenious systems of the Spanish orthographists, Ycair and Lucas, contribute much to the ordering of the Roman letter in print. Moxon in our own country tried to reduce the popular Dutch letter of his day to mathematical rules, with conspicuous failure. The French Academy took the unruly symbols in hand, and produced a standard of form which they tried to fix by Royal decree. Lastly, in our own day, eminent oculists have studied the question with a view to determining to what extent type may be modified so as to spare the sensitive organ to which it appeals. The valuable memoir on this subject recently contributed by the eminent French eye doctor, Dr. Javal, deserves special attention. His argument for a reform of the alphabet is based on admirable theories; but what he really proves, when he comes to give practical form to those theories, is, to my mind, the futility of attempting to subordinate typography to mere laws of hygiene. Dealing with each letter separately, he practically destroys the harmony which at the present time—to lay minds at least—is a main element in the legibility of type, and corrects the alphabet into a form which would try the eyes and temper of readers as much, if not more, than it does in its present unregenerate state. Dr. Javal's theories, however, are full of suggestion as to what are some of the broad tests of legibility in type. What he points out is this:—

1. That the eye is, after all, the sovereign judge of form.

2. That, in reading, the eye travels horizontally along a perfectly straight line, lying slightly below the top of the ordinary letters. So that the width of a letter is of more consequence than its height, and the upper half of it than the lower.

3. That, in reading, the eye does not take in letters but words, or groups of words.

4. That type which by its regularity of alignment, its due balance between white and black, its absence of dazzling contrasts between thick and thin, by its simplicity and unobtrusiveness, lends itself most readily to this rapid and comprehensive action of the eye, is the most legible.

5. And that such type, as I hope to demonstrate by some illustrations, is on the whole the most beautiful.

Before proceeding to a brief historical survey of the different epochs of the Roman character in typography, I must detain you for a moment with one or two definitions necessary to a clear understanding of our subject.

I show you on the screen one or two letters of an enlarged size, forming the word

Manly

There is a capital letter and four small, or, as they are called, lower-case letters. Of these, two—the "a" and the "n"—occupy what is called the line of the letter. The "l," like the capital "M," rises above the line. The "y" descends below it. The space between the top of an ascending sort and the bottom of a descending sort marks the full size of the "face" of the letter. Turning now to the capital letter, you will see that it consists of thick and thin lines, also of certain fine cross strokes at the extremities of these lines, called "serifs." The serif may be flat, that is, forming exact right angles with the perpendicular lines, or it may be the base of a triangle produced by the expansion of that line at its extremity; or it may be bracketed or joined to the line by curves. These serifs are not confined to capitals, but are used to finish the straight strokes of the lower-case also, being attached of course in the same manner as they are to the capitals.

I ask your attention to these points, because, as we shall see, not a few of the fashions of the Roman letter have been imparted by modifications either in the thickness and thinness of the letter strokes, the length or shortness of the ascending and descending sorts, or in the length and method of attachment of the serifs to the main lines of the letter.

Coming now to the earliest appearance of the Roman letter in typography, I need scarcely remind you that, as regards the form of their characters, the first printers were absolutely unoriginal. They adopted, as was most natural, the common writing hand of their country as their model. Their aim, in the first instance, was to simulate as closely as possible the manuscripts of their national scribes. It did not enter into their scheme to improve upon their copy, still less to strike out a line of their own. Their hope of profit consisted in successfully deluding their readers into the belief that the new books were written books, produced by a swifter and cheaper process than the laborious pencraft of the scribe. Consequently they followed their copy painfully and rigidly, reproducing all the scribe's mannerisms, his archaisms, his pedantries, even his blunders.

The German inventors of 1450 printed in black letter, not from choice, but from necessity—to avoid detection in a hazardous enterprise. And in like manner, 15 years later, the first Italian printers, in the monastery of Subiaco, although Germans, and naturally more familar with the Gothic form, had no choice but to make their first types in close imitation of the characters used in the Italian manuscripts of the day—that is, of the Roman characters.

They had beautiful models to work by. Caligraphy had just then touched its high-water mark, and some of the productions of the Italian scribes (as the photographs on the screen will testify) are specimens of rare beauty. If the first types of the Roman press are indifferent and crabbed in point of form, it is not the fault of the copy, but of the craftsmen who, wedded to Gothic ideas, failed to do proper justice to what, to them, was a foreign model. The photograph before you of the first page of the Subiaco Livy will show you how imperfectly the spirit of the round national character was at first caught, and how difficult the artists found it to discard entirely their German prejudices. Still we may regard with reverence the first appearance in print of a type destined to become the dominant character of typography—the character whose fortunes, good and ill, it is our business to follow to-night.

The manner of the scribes was better caught by Sweynheim and Pannartz when they removed their press to Rome, as also by many of their immediate successors. A few specimens of some of these works are on the table—that of Ulric Hahn being well worth notice. You will observe that more respect is paid to the round character of the letter, although in some cases, as, for instance, in the illustration, now on the screen, in the matter of ligatures and contractions, a great deal of care has still been taken not to improve on the written model.

For a few years the Roman letter remained in an immature and experimental stage, struggling on the one hand to free itself from the foreign features imported into it by the monks of Subiaco, and on the other to emancipate itself from its thraldom to the scribe. It was not till John and Vindelin de Spira took it in hand, in 1469, that it can be said to have emerged fully from the semi-Gothic into the pure Italian character. Even the Venetian artists fell short of the standard given by the scribes. They gave roundness and clearness to the form, and improved the capitals, but they left the lower-case somewhat ragged and irregular, and lacking in proportion.

It is easy to account for the difficulty which the early printer would experience in engraving his first alphabet. The manuscript, however neat and regular, would have no two letters exactly alike. In the same page there might be 20 capital M's. Of these, one might be broader than others, and one narrower. Some might be shorter, others taller than the average. Some might be exactly upright, others a little off the straight. In some the middle angle might dip to a level with the foot, in others it might barely descend half way. The printer would have to select one and only one of these as his model, and having produced it in type, adhere to it throughout. If, for instance, he selected a narrow M with a short middle angle, all his M's would be of this kind. The free hand of the scribe would be reduced at once to the stiff regularity of the typographer. If the models were well selected, the appearance of the printed page would be neater and more precise than the manuscript—albeit less spirited. If, on the other hand, poor models were taken, or those models badly produced, the defects would recur with painful precision; offending the eye in print far more than in the written page.

Thanks to uneven casting, bad inking, and rough press work, many of the earliest types presented irregularities among themselves which produce an illusory resemblance to writing—an illusion which has more than once puzzled students of early printing not acquainted with the extraordinary variations which the same types, imperfectly cast or badly worked, are capable of exhibiting in print.

Indeed, experimental Roman types like those first used in Paris, or by the mysterious printer of the "R bizarre" (one of whose books is on the table), or John of Westphalia in Holland, show most of the irregularities of the scribes without their brightness. Nor was it till the printer emancipated himself from the writer, and began to model letters for himself, that the art emerged from its experimental stage, and entered upon its brilliant classical epoch.

Before quitting this first stage, let me show you a fine specimen of Roman letter in MS. taken irom a Venetian copy-book of 1523. Although later than the date we have reached, it gives a fair idea of the written character at its best period.

The pioneer of the classical Roman letter was Nicholas Jenson, of Venice, a specimen of whose type is before you. The beauty of his performance was so universally acknowledged at the time that he received the unmerited credit of having invented the Roman letter. His merit was rather that he selected the best letters of the best models, and brought them, with an artist's touch, in subordination to the rules and requirements of typography. His letters are round and clear. The white of the interior (the "counter") is sufficient to give an appearance of lightness, but not so open as to give the body marks an appearance of weakness. The alignment is beautifully regular without being painfully trim. The ascending and descending letters are well proportioned to the size of the ordinary letters. The serifs are gracefully triangled, so as to combine strength and elegance. The character has plenty of individuality without forfeiting its simplicity; notice particularly the capitals, the round sorts of the lower case, such as the "c," "e," and "o," and the oblique top serifs of such letters as the "b," "l," "m," "n."

Jenson's models were destined to achieve European fame. In his own country the celebrated Aldus used them, putting into them—the capital letters especially—even more freedom and grace than his master. Notice, for instance, in the specimen before you, the capital M, also the Q, the tail of which has been a vent to the exuberance of the Latin typographer in all generations. Aldus was able to be bold as well as elegant. His heavier Roman is often massive and dignified; it lacks, perhaps, some of the grace of his earlier efforts, but the rugged, well-balanced letter, faithful still to the Italian model, is eminently readable. A fine specimen from a book printed by Rossi in Venice, about 1500, is before you, and will give a good idea of the heroic style of this early school.

Abroad, there was at first some hesitation in adopting the new Italian letter. The popular prejudice, especially among the religious orders which most affected printing, ran in favour of the Gothic; and in Paris, where, as we have seen, an early form of the Roman was introduced, it became necessary for the first printers to abandon their earliest attempts in favour of the more familiar type. When, however, they came to adopt the Jenson fashion, they put it to brilliant service. Geoffroy Tory, as we have seen, took upon himself to reduce the capital letters of the alphabet to an artistic system, and his pupil, Claude Garamond, at that time commissioned by the king to furnish types for the Royal Printing House, entered with feeling into his master's precepts.

Garamond's Roman became the model type of Europe. The specimen before you will give a good idea of the grace and proportion of this famous letter. It is the work of an able punch-cutter. The clean cut and finish of each letter was an advance on anything which typography had yet achieved, while the regular alignment—or, as typefounders would term it, justification—of the fount bears evidence that letter founding as well as letter engraving had already come of age. The combination of strength and grace in the form of the letters is admirably balanced. Garamond's fine strokes have a definite thickness, and his triangled serifs are eminently calculated both to resist wear and retain their clearness.

The Stephens of Paris, Plantin at Antwerp, John Day in our own country—three of the greatest printers of that golden age—all owed their inspiration, if not their actual types, to the French genius. Garamond's pupil, Le Bé, is said to have furnished Plantin with the magnificent Roman which made his press so famous. A specimen of one of these founts is here shown. And in the typography of the equally famous Elzevir press the influence of the Parisian artist is clearly discernible. The Elzevir types were cut by Christophel Van Dijck, who, while preserving to a considerable extent the general form of the Garamond letter, compressed and compacted it into the trim and business-like form which adapted it so well for the special work of the Dutch typographers. It is, as you will see by the specimen before you, a letter for use first and ornament next. The strokes are strong, the serifs short and well triangled, and the contrast between thick and thin is reduced to a minimum. Van Dijck's round letters are perhaps open to the criticism that they appear somewhat small beside the square, a defect which is always apparent unless the punch-cutter cuts these particular sorts a trifle large in gauge. It may also be urged that, for simple legibility, the ascending strokes of the Elzevir tall letters are too tall. The Dutch type was presently to take its turn as the prevailing fashion.

Previous to that, however, we must notice that the Parisian fashion had been adopted in England with conspicuous success by John Day, the only typographer of note in the 16th century of whom we can boast. He certainly had no native model from which to copy. Pynson's type, the earliest in England, had almost certainly come from a rough disciple of the Venetian school in France, and after him no one had done anything towards improving the character. Day, however, was a type-founder as well as a printer, and his fine Roman letter, especially in its larger sizes, nobly redeems the English typography of his century from almost unmixed reproach. Day treated the letter as Plantin did, boldly and vigorously, and not wholly without originality.

In one other British press the Garamond type made a brilliant appearance—that of the Huguenot printer, Vautrollier, whose Latin Testament of 1574 is perhaps as good as anything produced in his day. Unfortunately for our boasting, both printer and type came from abroad.

Before quitting this epoch I must call attention to one other fashion which has a claim to be included among the classical models of the Roman letter, of Europe. The printers of Basle early achieved a great reputation for their excellent typography. In the matter of the Roman letter, they were to some extent original. Whether with an eye to the picturesque, or in deference to a northern predilection for Gothic forms, Froben adopted for his founts a curious mannerism, not altogether unknown before his day, which consists in thickening the round sorts—for instance, the "o"—not at opposite sides of the letter, but obliquely. The illustrations before you will explain this fashion. The fount is what type-founders would call cut "on its back," an effect which relieves the general appearance from commonplace, while interfering comparatively little with its regularity or grace, or—in Froben's case at any rate—with its legibility. Froben's fashion was copied, sometimes exaggerated, by other northern printers. The specimen before you is that of his fellow-townsman, Isingrin. Christopher Froschowwer, of Zurich, also used it with great effect, as did many of the German presses, amongst others that of the younger Peter Schoeffer, at Mayence.

I have now described the four early classical fashions of the Roman letter; beginning with Jenson, taking new shape under Garamond, receiving precision from the Elzevirs, and enjoying a little unconventional liberty at the hands of Froben.

We have now to turn to a less agreeable epoch, an epoch of backsliding and degradation, when the sense of beauty in typography gave way to sordid economy and dull utilitarianism, when printers forgot to be original, and readers suffered patiently whatever print might be imposed on them.

Even France, with a Royal patronage of printing, and an Academy of Sciences to furnish it with models, fell off from the excellent models of Garamond to the more monotonous and less artistic types of Grandjean and Sanlecques. In Holland, the Elzevirs themselves allowed their work sometimes to become slovenly and dull. Germany stolidly relapsed into a gross form of her national black letter. And England, without an artist to help us, distracted by civil wars, manacled by privileges and monopolies which stamped out competition and ambition—with bad ink, bad paper, bad presses, bad workmen, drifted back year by year, till she could hardly boast a Roman fount worth the name. Day's letter, indeed, held its own, and reappeared occasionally; but for the rest, we sold ourselves, typographically, body and soul to the Dutch. The average specimen of English 17th century printing is a melancholy study. The Bibles, the broadsides, the classics of the day compete with one another in grossness. Any merit which a fount may have possessed was obscured by bad casting, or a continued use of types after the face was worn down by age, serifs broken, and the counters of the letters clogged with ink.

The Dutch influence became increasingly marked towards the close of the 17th century, at a time when, in its own land, it was sinking to decay, and wasting its energies in an attempt to become microscopic. The Oxford University Press was furnished with Dutch matrices. Moxon, a type founder who attempted to apply mathematics to the Roman character, wrote enthusiastically of the Van Dijck letter; but his own specimens are a dismal commentary on his own incapacity to copy his models. English printers bought their type from Holland direct; and as late as 1713, a leading Scotch printer, James Watson, boasted that he had nothing but Dutch letter in his office.

In this third epoch of the Roman letter—the epoch of the decline and fall—there is no new fashion to record anywhere that is not either commonplace or coarse.

The renaissance of English—and I might almost say of European—typography dates from the establishment of William Caslon as a letter founder in 1720. Caslon's Roman was modelled on the best form of the Elzevir letter. It is bold, regular, and clear; the fine lines retain a distinct thickness, while the thick are redeemed from the uninteresting clumsiness of the degenerate Dutch school. His serifs, moreover, while somewhat more delicate than those of the Elzevirs, are strong and durable.

A great merit of Caslon's letter is that it is truly justified, that is to say, every letter is cut not only as an individual, but as one of an alphabet, every member of which must harmonise and range, and be closely related to every other. This feature had been lamentably lacking in the period of the decline. Caslon's brilliant success, no doubt, is mainly due to the excellence of his models; but much of it is due to the care with which he justified and cast his founts. Not only did he study the relation of one letter to another in the same alphabet; but in producing his different sizes, he carefully preserved the uniformity of the series, so that a printer desiring to use two sizes of type in his work, might be sure of the same style of letter in both sizes—a luxury he had rarely been able to count on in dealing with the Dutch founders.

Here I should like to correct a common fallacy with regard to the gradation of type sizes. It is assumed that a perfect series of Roman founts may be produced by taking the letters of one particular size, and reducing or enlarging other sizes from it in exact geometrical proportion. This is a mistake. In reducing from a large size to smaller, while the width of the letter follows the strict proportion, the height of the ascending letters undergoes a slightly increased diminution, while the thickness of the fine strokes and serifs is usually reduced at a less ratio than the thick. The width of a letter is far more essential to its legibility than its height; and from Caslon's day it came to be a special merit of the English Romans—as contrasted with those of the French—that the height of the ascenders were somewhat curtailed, without reducing the fullness of the ordinary face of the letter.

The new English fashion gave the *coup de grâce* to the Dutch, and naturally provoked many imitators. The most distinguished of these was Baskerville. What he attempted, and succeeded in doing, was to refine the serifs and thin strokes, so as to bring into stronger relief the thick, preserving at the same time the roundness and openness of the Caslon model. The effect was showy and attractive, and when printed, as his books were printed, in bright ink on a highly-glazed paper, the result was very brilliant. The fault about it, and what caused the fashion to be comparatively short lived was that it was too brilliant. It dazzled and fatigued the eye, and was too delicate to wear. Artistically, Baskerville's type is one of the most beautiful we have had. But it was ahead of its time, and English printers and readers, after looking at it admiringly for a few years, called it meretricious, and went back to Mr. Caslon. Baskerville achieved a *post-mortem* success in France, whither his types were transferred, and appropriately used for the great Kehl edition of the brilliant Voltaire. The fashion survived lor a long time in France, where, till comparatively recently, it was held to be a merit in an old style type, intended for fine work, to be known as "after the manner of Baskerville."

In England, meanwhile, up to nearly the close of the last century, the Caslon Roman held its ground. The great artist's apprentices kept closely to their master's models, with a tendency perhaps to lighten the face. His Scotch rivals had already made the character famous in the admirable works of the Foulis press; and others, like the Frys, who began in avowed imitation of Baskerville, found it incumbent on them to revert to the older and more popular fashion.

This security was suddenly disturbed by

the rising fame of the Italian typographer, Bodoni, whose magnificent productions became the envy of European printers. Bodoni's style was a marked departure from the old classical models. He sharpened his fine lines and thickened his heavy lines simultaneously, thus producing a strong and dazzling contrast. Added to this, he lengthened both his ascending and descending sorts, and finished up his straight strokes with a very fine unsupported horizontal flat serif. The regularity and precision of his work are remarkable; the type, exhibited as it was in luxuriously printed specimens and wide margined pages, made a deep impression in England, where for a short time ensued a competition for his services. One or two English books were, as a matter of fact, produced at the Parma press, and by one of those mysterious caprices of fashion, the popular taste veered completely round in favour of the new Roman. The Caslon letter for the time was doomed. At enormous sacrifice the old punches and matrices of the English founders were discarded, and a race ensued for the production of the modern Roman. Perhaps the new style is seen to best advantage in the productions of the Bulmer and Bensley presses.

De gustibus non est disputandum. To many eyes the modern fashion lacks all the graciousness and dignity of the old. Its straight hard serifs, its stiff interiors, its harsh contrasts of thick and thin, more than nullify the passing advantage of exact lining and delicate finish. But apparently no remorse for the abandonment of the old style was felt at the time; the public was well pleased with the new style, and with one accord deserted the old.

A change of equal importance was in progress abroad. France, the land of revolutions, had long since broken away from the traditions of Garamond. As early as 1693, a commission of experts was appointed by the French Academy to inquire into and draw up rules for the best form of the Roman character, for the use of the Royal Printing-office. It is much to be regretted that M. Jaugeon's report and drawings—the result of this interesting inquiry—only exist in manuscript. His letters were designed on a highly elaborate geometric system, on a square subdivided into 2,304 small squares. It is doubtful whether they were an improvement on the letters already in use. The outcome of the inquiry, however, was the reformed "King's Roman," cut by Grandjean, and continued by Alexandre, a specimen of whose alphabet is shown side by side with the more free and artistic alphabet of Garamond. It is noteworthy that Grandjean, although consulted by the commissioners, declined to regulate his alphabet entirely by the mathematical rules laid down for him. He referred his models to the supreme tribunal of the eye, and probably produced a far more satisfactory letter than had he worked slavishly within the confines of his 2,304 minute squares. His chief modification of Garamond's type was the substitution of a flat for a triangular serif, the straightening of the hitherto oblique top serif, a more marked contrast between thick and thin, and the addition of the unseemly double serifs to the ascenders, and the cross mark on the "l"—badges of the Royal proprietorship of the type.

Luce, who came half a century later, ruthlessly elongated the alphabet, shortened and fined down the flat serifs to a reprehensile extent, restored the oblique serif of Garamond (but too late to be of much use) and gave an air of general cramp to what was before generous and distinguished. Luce, in some of his founts, carried this narrowing process still further, increasing the height as he contracted the width, and produced a type, highly praised by Fournier and other *savants* of the day, which was styled *poetique*.

Firmin Didot, who followed, succeeded in re-shaping the Roman into something like its old proportions; but in doing so he extinguished the last spark of the antique, and produced the trim, sleek, gentlemanly, somewhat dazzling fashion, which has since, I venture to think in degenerate forms, continued to rule in French typography. The slide before you gives Didot's royal alphabet in detail, and while it is on the screen I may anticipate by remarking that the rage for the English "fat face," about 1815, penetrated into France, and, as will appear, the Royal Printing-house there furnished itself with a set of characters after this model, cut in London. You will notice the violent contrast between thick and thin strokes, and the dangerous fineness of the serifs. To complete the evolution from Garamond to the modern French, we have the alphabet of M. Marcellin le Grand, narrow and stiff, and, with due respect to foreign taste, unpleasing to English eyes.

Here, then, with Didot, we close the epoch of the Renaissance. It began with Caslon, Baskerville followed, but did not supplant the old master. What Baskerville failed to do Bodoni achieved, and he and Didot between them killed the old style, and left us our modern Roman.

The epoch which ensued, occupying the first half of the present century, was, so far as the Roman character is concerned, an epoch of respectable commonplace. But unlike epochs which preceded it, it ended better than it began. The new Roman was barely established as the prevailing fashion, when a vulgar taste for fatter faces asserted itself. The demand was promptly responded to by the founders of the day, Robert Thorne leading the way. Others outstripped him in the race; and about 1820, or rather before, a face like that before you was both fashionable and popular for certain works. As a foil to this exaggerated fatness, the new Roman also began to appear in forms of extraordinary leanness and compression, of which a specimen is exhibited in contrast to Thorne's style. Those fashions—passing fashions, happily—represented a reactionary movement against the tendency to lighten and refine the Bodoni Roman to forms of excessive fineness. The rise of the newspaper press, and the introduction of steam machinery, made it necessary to cast types in much harder metal than heretofore, so as to defy the ordeal of the new process. In this metal it was discovered that the serifs and fine lines were capable of the most delicate treatment, and the founders of the day entered on a competition for the sharpest and finest of effects. It also came to be a consideration with printers how much could be "got in" in a line, and the compositors' tariff began to exercise considerable influence on the style of the Roman letter. A tendency developed itself, particularly among the Scotch founders, to condense the letter after the French style, and the Scotch letter in its day achieved considerable favour. It was neat, and clear, and delicate, and "got in" considerably more than the ordinary style. The English founders, however, resisted the innovation, and adhered to the rounder forms as more readable and better calculated to retain their clearness. The specimen before you represents several of the most familiar varieties of the modern Roman. Clearness was not, however, the main ambition of the punch-cutters. The applause bestowed on the productions of some of the famous London printers about 1820, notably those of the Bulmer press, fired their emulation to dazzle the public eye. They prided themselves on the exquisite fineness of their hair lines, the graceful sweep of their curves, the *crescendos* and *diminuendos* of their round letters. But all the while they were drifting away from the canons of easy legibility. It may be a pleasant sensation to some people to be dazzled, but the majority of readers prefer more homely and restful effects. The old artists of the classical school were never egotists. Egotism has been and remains responsible for many of the defects of modern typography.

We come, finally, to our last epoch—the present. It was ushered in, about 1845, by the revival, under the auspices of Mr. Whittingham, of the Caslon old face. The old master, thought to be dead and buried, sprang again to life as potent as ever. I need scarcely remind you of the result of this revival both at home and abroad. Side by side with the new and improving Romans of the letter-founders appeared founts cut after the antique, with all the superior finish of modern workmanship. Founders did not venture in their reproductions to copy all the strong lines of the old models, but embellished their "mediævals" with the delicate tapers and hair lines of the modern school. The typography of the last half century owes a great deal to this opportune return to the past; and the continued favour of the old styles, I venture to think, is a hopeful sign for the future.

For newspapers, and for a great deal of bookwork, the mediæval is no doubt unavailable. Indeed, under present conditions, the Roman must, of necessity, form the staple character of typography; and in its present serviceable forms is likely to hold the field for a good while yet. It is the work-a-day letter. The old style is the *lettre-de-luxe*.

I should mention, as perhaps another significant tribute to the genius of the old artists, a recent tendency to revive the fashion which I have previously described as the Basle style. On the illustration before you (which presents various forms of modern old-style) are shown two specimens of this revived model.

In conclusion, I venture, as a humble member of my ancient art and craft, to remind you that the typefounder does not profess to be the educator of the printer and his readers, but their servant to command. It is for the reading public, in large measure, to determine what shall be the future of typography. If it is content to read hardly where it might read easily, if its taste run towards vulgar ornament or meretricious display, if it too easily tolerate bad type, or even good type badly printed, it will not fail to get what it wants. If, on the other hand, it demand simplicity, and grace, and legibility, I doubt not it will obtain them. *Simplex munditiis* is a motto for Roman letters as well as for Roman maidens.

I take it as a hopeful sign that the æsthetics of typography are at the present time being studied by men of artistic taste and authority. The result cannot fail to be of benefit. For printing, in all its career, has followed close in the wake of its sister arts. When they have flourished, we have had our most beautiful books; when they have declined, printing has gone down below them. It is a bad day in the history of any art when it becomes a mere trade, and the "Art which preserves all other arts" should by all means be saved from that calamity.

DISCUSSION.

The CHAIRMAN said he felt quite incompetent to deal with this comprehensive and interesting paper as a whole, but one or two points had occurred to him in listening to it. He was much pleased to hear the high place assigned to Nicholas Jenson in the improvement of the typographical art, for he had always been struck with the beauty of his types when they had fallen under his observation, and was glad to find that he had been an important link in the chain of typographical development. Although spoken of as a Venetian, he was by birth a Frenchman, and it was somewhat remarkable that though the French art at that period showed a tendency to the irregular and grotesque, this particular Frenchman took quite the other direction, and produced work of more than ordinary finish. The subject was too extensive to be gone thoroughly into by anyone in a single evening, and there was a large field on which Mr. Reed had not been able touch at all—viz., the development of non-Roman type, partly Greek, on which there was much to be said, especially as to the extraordinary relapse of the printers of later times, when they used the abominable contractions which so disfigured Greek type, and rendered it so difficult to read. The reference to Plantin's excellent Roman type reminded him that in the King's Library at the British Museum there was a beautiful specimen of his italic type amongst the Tudor exhibits. It was the first Spanish book ever printed by Plantin, being a sermon preached before Philip and Mary at Kingston-on-Thames by the Archbishop of Toledo, who was then the king's chaplain. The question of the interchange of types between different printers was interesting, and also that of the interchange of woodcut frontispieces. Amongst some recent purchases in the Museum was an old Mexican book which contained a frontispiece which had been exported from London only a few years before; he was not sure the English printer was not John Day, and it was curious to find that though England and Spain were at war soon after, this frontispiece should turn up in Mexico. Another example was that of an English book printed in Queen Mary's time by Tottell, which had for frontispiece a cut that had appeared in Germany ten or twelve years before on the little page of a book giving an account of the Diet of Worms; the subject was "Pyramus and Thisbe," treated in so grotesque a manner that it seemed likely to have come under the notice of Shakespeare, and given him the idea of parodying the story. Some little time ago a book was purchased for the Museum which was printed by the Jesuits in Paraguay in 1734 in the Indian language; the typography was peculiar and very rude, and it was stated in a history of the Jesuits in Paraguay that it was printed from wooden types. He should be glad to have the opinion of an expert whether this was possible, but the theory derived some plausibility from the fact that at that time the Jesuits were on bad terms with the Spaniards, who held the mouth of the Rio Plato, and probably prevented any commerce between Europe and Paraguay. Type could not very well be imported therefore, and he doubted whether the Jesuits had the power of casting metal types themselves, if not, they might have recourse to some of the hard woods of the country for the purpose. Speaking of printing in remote countries, he might refer to a Portuguese book printed at Goa about the middle of the 17th century, which ought to have been a splendid specimen, for it celebrated the restoration of Portuguese independence, but in fact it was about the worst production he had ever seen. He had been much struck with the beauty of the books recently printed in Mexico; he could not say whether the type was cast there or imported, perhaps from France, but at any rate it was evident that typography was cultivated there to an extent one would not have expected; the printing was much better than most of that which came from the United States.

Mr. LANG said he had paid a good deal of attention to this subject from the point of view of an ophthalmic surgeon, and he came to hear what were the views of a type-founder. It was absolutely essential in these days, when every one had to study a great deal, that he should be able to read without an undue strain being thrown on the eyes. In Germany the evil effects of bad type were very marked. Bismarck was credited with the statement that so long as he was in power he would not permit any change in the type, and consequently shortsightedness had rapidly increased in spite of all that doctors could say, and he should watch anxiously to see whether any improvement would now be introduced. The light from the windows had been attended to, as it had been in our modern Board schools, but the type, which was more important still, had been entirely neglected in Germany; and though the scientific books were generally printed in Roman type, newspapers and ordinary school books were still printed in the very bad German type, and any one who had been in Germany must have noticed the great prevalence of short sight, which, though it was not of much importance when only present in a slight degree, was likely to lead to total loss of vision when it became more marked. The English were not so studious as the Germans; a young man would perhaps spend 14,000 hours in study, and 7,000 in exercise or recreation, but in Germany he would devote 21,000 hours in study, and consequently the badness of the type was of even more importance. In the lowest class in a school you would find only 1 or 2 per cent. of children with short sight, but this increased as you went upwards, until in the highest class there would be only one out of 20 or 30 who escaped. It was very important, therefore, to know what kind of type was likely to produce short sight in England, especially as in the future reading would be much more universally practised than it had been in the past. He was pleased to hear from Mr. Reed that the so-called fancy type was not to be encouraged, and that the tendency would be to revert to the Caslon and types of that character.

Mr. EMERY WALKER said it was very interesting to notice, in looking at a historical series of slides, that the changes in the direction from beauty to ugliness corresponded with the changes in the art world at that time. You would expect to find in Venice at the beginning of the 16th century, beautiful types, and at the beginning of the 19th century, looking to the prevailing ugliness in architecture and all the other arts to find the type ugly also, and that was exactly what had been shown.

Mr. JOHN LEIGHTON said, in dealing with the fashions of type Mr. Reed confined himself to the forms used to impress their inked surfaces upon paper, and more particularly those used in the combination of solid pages of matter, as in the book or newspaper; and noted the transition from the German black letters through the Roman italicised version to the meagre French, and to the revised Renaissance of the present day that grew out of the matrices so happily preserved by the Caslons. When the Roman capitals became united to a lower-case, that was evolved from a free Gothic script, as upon Roman inscriptions we find no lower-case or figures. Of the worst period of typographic characters, extending from the beginning of the present century to the middle of it, the "fashion" came from France, the letters being narrow, with black perpendiculars and very fine horizontal lines, such as was now but little used, even in France itself, except in the Imprimerie Nationale at Paris. In types there was no copyright, as Sir Charles Reed once said to him, and from the earliest times he believed that types were evolved and grew, the face little resembling the root. To see the form of type it is necessary to see it worked upon paper, and he would refer to a unique and costly example of his own, due to the taste and enterprise of the late Thomas Longman—"The Life of Man Symbolised," being composed of all languages and characters of the periods of their authors, the Latin appearing in Roman capitals, Chaucer in black letter, the Italian in italics, and the modern in the type of the period.

Mr. JAMES FIGGINS said the trade of typefounding had always been in very few hands, and it was extremely difficult to deal with this subject, at any rate in the present day, without making allusions almost of a personal character. It was easier to criticise when you went back two or three centuries; and Mr. Reed had very judiciously stopped in time. Looking at the general progress from one form of character to another, it would have to be admitted that what was called general utility had been the great enemy to anything like art in typography. The moment a letter was produced which was useful for some particular purpose, it was found that it did not suit the requirements either of the printer or of the workman, and many forms which would have been thought very good had been rejected because, although adopted at the request of the printer, that as much as possible should be got in on the expensive duty-paid paper he was then compelled to use, it was extremely difficult to read, and no doubt that class of type was responsible for any damage to the eyesight of that generation which came from reading. But when a more complete form of character, one less dazzling to the eye, was introduced, it was found that the printer could not make up so many galleys in that as in the other, and the consequence was that the whole time and labour spent on those founts was thrown away, because the printer could not make the same amount of money in setting a page of type; and the employer refused to pay anything extra. Thus what were known as the thin founts were rejected, and the whole ground had to be gone over again. They were suffering in the present day from a similar tendency. Founts gradually grew to be wider; but looking at many newspapers of the present day, it would be seen that they were utterly sacrificed to the requirements of the composing machine, and instead of adopting the variety of widths necessary, and the different forms pointed out by Mr. Reed, they were limited to a definite width, irrespective either of beauty to the eye or legibility in reading. Of course it was impossible to allude specifically to any particular paper, as it might be thought that he referred to one particular machine or fount of type; but he would ask any one with an eye to beauty in typography to examine various newspapers, and he would discover for himself which had to meet the requirements of the composing machine and which were produced with a view to really artistic effect from a typefounder's point of view. In looking back at the history of type-founding we must not forget how few were the punch-cutters who had to produce these Roman characters;

formerly the whole number in Europe might be counted on the fingers of one hand, and even in the last century two hands would have sufficed to count them with, and there were very few besides who were competent critics of their work. To a great extent, therefore, the type had been either produced quite haphazard, or for some particular purpose, which might or might not have been achieved. In the present day things were very different. Types of durability, exceeding any once conceived possible, were now produced, and, on the other hand, a great deal of art threatened to be sacrificed to the introduction of the composing machine. A great deal of criticism had been cut away by excluding what were known as fancy or jobbing type, but if Mr. Reed would on some future occasion favour them with his views on that point, there would no doubt be an ample discussion, because opinions differed very much both as to their utility and beauty. The main point was to what extent the Roman characters were influenced by the requirements of the day, and he ventured to think that though many of the early models were extremely good, the present method of producing them was so far superior that, even if inferior in design, which he did not admit, in their general effect and utility they were far superior.

Mr. HUTT said Mr. Reed spoke of the type founder as being the servant of the printer and of the public, but he would go further, and say that the printer was the servant of the publisher, and very often did not serve him properly. If a publisher tried to improve the art of type-setting, the printer would often throw every obstacle in his way. Printers, too, were fond of making their own type, and every form of type made by printers was hideous in the extreme. It was always a marvel to him why they did not copy the best forms, and go to the Caslon at once. The art world owed more than they knew to Mr. Emery Walker, for what some people would call his fad, as far as old-faced type was concerned. He had found it very difficult to get a Caslon type, and when he complained to a printer of the wretched modern-faced type, and said he wanted a good Caslon, he said he believed they had one somewhere locked up which his grandfather had used. He believed there was a lot of old Caslon type about, which the public would appreciate. He had an interesting letter the other day from a working man, who had brought a copy of the 6d. "Westward Ho!" and who said it was beautiful in every way but one; the type on the cover was very good until he came to the last line "Price 6d.", which was not equal in beauty to the rest; and that was perfectly correct, and in the later editions the Clarendon line was replaced by a Caslon lower-case to match the rest of the title. If every publisher in his humble way would try to improve the beauty of the work which he issued, he was sure the public would appreciate it, and if type founders would put themselves forward more, as masters of the printers instead of servants, they might do a deal of good. He hoped this excellent paper would be only the first of a series.

Mr. REED said one point occurred to him in connection with Mr. Lang's remarks, and that was that a child did not read in the same way as an adult, but spelled out the words letter by letter, and possibly therefore a different style of type might be more suitable for school books from that which was best for the ordinary reader. Certainly very little consideration was shown for the tender eyes of children, but he hoped the influence of gentlemen like Mr. Lang would lead to a reform in that respect. With reference to the appearance of type, due regard must always be had to the quality of the paper, the width, and the margin. The same type printed roughly on coarse paper, then finely on good paper and hotpressed, and luxuriously on a large page with a wide margin, would hardly be recognised as being identical. In regard to paper and ink it must be remembered that our forefathers were lamentably deficient.

The CHAIRMAN, in proposing a vote of thanks to Mr. Reed, said according to his observation most German books still retained the Gothic character—not school books alone, but those printed in the Austrian Empire, generally speaking, adopted the Roman character—whether that was due to the absence of Bismarck he did not know; but he should be interested to see whether any improvement in printing followed the disappearance of that great man from public life. There was one series of books issued in Germany in the Roman character, which ought to be one of the best models of clear, clean, legible printing, the Tauchnitz vols., and to a great extent he believed that was the case. One English publication also ought to be a model of perfection in its way, but he was not quite so sure about that; he referred to Bradshaw's Railway Guide.

The vote of thanks was carried unanimously, and the meeting separated.

Miscellaneous.

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PRODUCTION OF CIDER IN FRANCE.

The United States Consul General in Paris in his last report says that the apples which are used in the production of cider are grown in about 60 of the 83 departments into which France is divided. The quality of the fruit largely depends upon the condition of the soil. If the latter is laid out wet, the fruit is sour, producing a thin cider. A calcareous soil gives a mild, insipid juice, while a too sandy soil yields a juice wanting in tannin, the preserving ingredient of the liquid. The best soil is a mixture of clay and sand with plenty of moisture. Sweet apples contain the most sugar; they give more cider than the bitter ones, but it is flat, feeble in colour, and does not keep long. Bitter apples contain the most tannin and furnish the least cider, but the cider obtained is strong, generous, rich in colour, and keeps a long time. Sour apples are the least rich in sugar and tannin. They furnish the most cider of all the varieties, but it is of a very poor quality. After lengthy experiments, the professors in the French agricultural schools have decided that to make the best cider, apples ought to contain 80 per cent. of water, 17·3 per cent. of sugar, ·5 per cent. of tannin, 1·2 per cent. of mucilage, ·167 per cent. of fermenting acid, and ·833 per cent. of other substances. The tannin assists to clarify the cider and also to preserve it, the mucilage prevents the alcohol from turning the cider into acetic acid, and the sugar gives the alcohol. As very few varieties of apples contain the desired qualities in the proportions given, they are generally mixed, only those of the same season being used. There are some varieties which employed alone give excellent cider. They contain, in fact, all the principal elements in the right proportions. Such are, first season, Reine des Hâtives; second season, Fréquin-Rouge, Barbarie; third season, Pomme Bramtot, Marlin Féssard, Amère-de-Berthecourt, Rouge-Bruyère-Nouvelle, Bédan, and Peau-de-Vache-Nouvelle. The varieties richest in alcohol are—first season, Reine des Hâtives; second season, Pomme-de-Chat, Fréquin-Rouge, Argile-Nouvelle, Barbarie, and Rosine; third season, Binet, Bedan-des-Parts, Rouget, Belle Cauchoise, and Galopin. The varieties most rich in tannin are—second season, Marlin Fessard, Rouge-Bruyère-Nouvelle; third season, Pomme Bramtot. The only other varieties recommended are—first season, Blanc-Mollet; second season, Jaunet Pointu, Précoce David, Ecarlatine, Vice-President Heron; and third season, Pomme Marabot, Pomme à Tannin, and Marie Lerand. In preparing for the press there are three methods of reducing the fruit to pulp. First by a machine known as a *tour à piler*. This consists of a circular trough, around which a stone wheel is made to revolve by horse-power. This antiquated method is gradually being superseded by two new varieties of machinery. These are the grater—a machine with small saw-like teeth set close together, and the crusher, a machine very similar to a coffee-mill, but much larger, and capable of producing from sixty to eighty hectolitres (hectolitre = 2·75 bushels) of pulp per hour. This is considered the best machine, as it does not break the seeds, the essential oil of which imparts a disagreeable flavour to the cider. The pulp is left in vats from twelve to fifteen hours to macerate, being occasionally stirred, so that all parts of it may be exposed to the air. Maceration heightens the colour of the product, aids in the disintegration of the fibrous tissue, and increases the ferments. Before putting the pulp into the press, the bottom of the latter is lined with a thin layer of straw, a wire netting, or small oak, or beech branches. Straw is objectionable, as it imparts a bitter taste to the juice, while the above-named woods yield a small additional quantity of tannin, so necessary to preserve the cider. About 95 per cent. of the apple is juice. Formerly it was not considered wise to express more than one-third at the first pressure, the second, third, and even fourth being made with water added. Now the press is considered best that expresses the most juice. The hydraulic presses now in use obtain from 65 to 75 per cent. of the pure juice at first pressure without drainage. The process of diffusion, so successfully employed in extracting the sugar from the beet root, has been tried in making cider. Formerly three vats were used, placed in a line one below the other. All three were filled with pulp, and into the first one was then poured as much water as it would hold. At the end of twelve hours it was allowed to run into the second vat, and after another twelve hours into the third vat. The product was somewhat improved if warm water was used. This method was employed only where presses were not easily obtainable. Recently, however, new methods of diffusion have been discovered by means of which the inventors claim to be able to get 85 to 95 per cent. of the pure juice. By these new processes the apples are not crushed but cut by a special machine, they are then placed in the diffuser and the water made to pass through. The peculiarity of this process is that the water does not mix with the juice at all but drives it out before it. Fermentation is accomplished by the aid of yeast which exists in the apple and is expressed with the juice. The principal object of fermentation is to change the sugar into alcohol. The first process is carried on at a temperature of from 12° to 18° Centigrade (54° to 64° Fahrenheit). If fermentation is slow, the juice is stirred vigorously with a bunch of twigs, and if that does not succeed, a little yeast in fermentation is introduced. This stage of fermentation is performed in either open or closed vessels, and in casks with the bung drawn. In this way the process lasts from five to six weeks. The bung is then driven in tightly, and a small gimlet hole made, which is kept open by a straw. Under these conditions the secondary fermentation is effected slowly, and the sugar is transformed into alcohol, the carbonic acid gas escaping through the gimlet hole. After a month or six weeks the liquor is withdrawn into air-tight casks, which are not quite filled. In the space left, the dregs are collected by the action of the gas; they can then be removed, leaving the cider much clearer. In cases where the tannin has been deficient, and the cider is not sufficiently clarified, 60 grammes of cachou, dissolved in a litre of cold cider, are added to every hectolitre. The tannin in the cachou precipitates all albuminous matter, and prevents the cider from turning black on exposure to the air. The method employed in Jersey is different, and is considered somewhat better, and Jersey cider has the reputation of being the best and most durable produced. The first process is accomplished in open vessels, at a temperature of 15° to 18° Centigrade. The cider is then drawn off into closed casks which are not quite filled. When sufficient gas has collected in this empty space to extinguish a candle, the cider is drawn off into other casks, the process being kept up until no more gas remains. All the casks used are well dried, well washed, and fumigated with brimstone. By no process is the juice considered to be cider under six to eight months. The best brands in France will keep from three to four years. It is preserved by pouring in enough oil to completely cover the top of the cider from the air. Champagne cider is of recent date, but Consul-General Rathbone says that the trade in it is already assuming considerable proportions. It owes its popularity to the facility with which it can be shipped and preserved, and to its sparkling qualities. A cider is prepared that can be kept in casks for five or six years and exported to India or South America. The apples used are very rich in saccharin, and the juice contains from 10 to 11 per cent. of alcohol. Before fermentation and to every hectolitre are added 50 grammes of tartar of potassium, and 500 grammes of chips of green beech. After fermentation the cider is heated by means of an œnotherme—an instrument used in the manufacture of wine—and instantly cooled again. This apparatus costs about £16. This process, however, is said to destroy somewhat the flavour and quality of the cider. The total quantity of cider produced in France in the year 1887 amounted to 295,606,674 gallons, as compared with 182,616,676 gallons in the preceding year.

AGRICULTURAL PRODUCTS OF THE PHILIPPINES.

The United States Consul at Manilla says that the principal products of the Philippines are hemp, coffee, rice, tobacco, corn, and fruits. The cultivation of hemp is a very simple operation, and as it yields a large revenue it is not surprising that it is a popular occupation among the people. This staple is the product of a species of plantain which grows wild on the Pacific slopes of the volcanic elevations of the Philippine islands, particularly the southern ones. Under cultivation the tree attains a height of 15 or 20 feet, with a trunk from 8 to 12 inches in diameter. In its green state it is crisp and juicy, and can be readily cut down with an ordinary carving knife. The preparation of the hemp for market is very simple. When the tree has properly matured, it is cut down and divided into long strips, which are shredded under a large knife kept in the proper position by a rude lever. This separates the juice and spongy matter from the fibre, and the latter is spread out in the sun to dry, after which it is packed in bales of about 240 lbs. for shipment. There are a large number of plantations owned by natives, as well as by Spaniards and mestizos, where the trees are set out in regular rows, and well cared for. The cultivation of the coffee tree has been followed to some extent for the past thirty years, but interest in this branch of cultivation has been renewed during the past four or five years, and it is expected that its export will increase annually. There is no way of ascertaining the area of land occupied by coffee trees nor the amount of coffee annually produced, as the trees are scattered in various parts of the archipelago. The largest plantations are in the province of Batangas, in the island of Luzon, but many of the natives have a few trees in their front yards, under the shade of the plantains, that may yield four or five bushels of coffee berries. The increase in production has been marked within the past few years. In 1887, a little over 5,387 tons were exported; in 1888, about 7,501 tons. Although rice is the native's principal article of food, there is not enough of it produced in the archipelago for local consumption, and more than 70,000 tons are imported annually. The tobacco industry in the Philippines employs a large amount of capital and a vast number of hands. The best tobacco comes from the provinces of Cogayan and Isabella on the island of Luzon, the average annual yield from these being from 60,000 tons to 100,000. Tobacco is also grown in the provinces of North and South Ilocos, Abra, Lepanto, Nueva Exija, and Union, all on the island of Luzon, and on the islands of Cebu and Panay. The tobacco produced in the former provinces is called *Igorrotes*, while that from Cebu and Panay is designated *Visayas*. In cultivating, the earth is well ploughed and harrowed and the seed sown in September. About six weeks later the young plants are transplanted about two feet apart, and the field is kept free from weeds, and otherwise carefully attended to until February, when the plants are almost ripe. The crop is gathered in March and April. It is then made up into "hands" of one hundred leaves each, the leaves of each hand being fastened together at the stem ends with strips of bamboo fibre. These hands are then hung up in rows upon bamboo poles under long sheds, which are open on all sides, and when they are almost dry they are piled up on the ground and allowed to ferment. The leaves are then dried again and packed into bales for shipment to Manilla, where they are repacked and pressed into bales for export, or sent to the factories to be converted into cigars and cigarettes. It is not sold by weight at the plantation but by the *fardo*, which contains forty hands. All the tobacco manufactured in the Philippines is made into cigars and cigarettes. The tobacco is classified at the plantation into first, second, third, fourth, fifth, and sixth grades, according to the size and quality of the leaves. In Manilla there are twelve large tobacco factories, one of which, La

Flor de Isabela, the factory of the Companía General, manufactures seventy-five brands of cigars, ten brands of cheroots, six grades of cut tobacco, and eight brands of cigarettes. These twelve factories give employment to about 11,000 persons. Besides these there are numerous small factories owned by natives and Chinese. Corn holds a very unimportant place among the agricultural products of the Philippines, although it is cultivated to some extent. All the corn produced is that known as maize or Indian corn. The method of cultivation is similar to that followed in more advanced countries, but the implements used are of a very primitive character. As a rule the land is ploughed with a sharpened stick drawn by a buffalo, after which a heavy wooden frame, about four feet square with long wooden teeth on the under side, is drawn over the ground to break the lumps. The corn is then hoed by hand, and all that is necessary thereafter is to keep the weeds down. No manure nor fertiliser of any kind is used. No attention is given to fruit culture, and mangoes, bananas, apples, guavas and numerous other native fruits grow without cultivation, and are gathered by the natives in the hills and even within the limits of the cities and towns, who bring them to Manilla and sell them in the streets and markets. Consul Webb says that no attempt has ever been made to export any of these fruits except a few mangoes, which are sent every year to Hong-Kong and other neighbouring ports, although it is quite probable that under a proper system of cultivation, grafting, &c., some remarkably good fruit might be developed that could be preserved or canned, and sold at a great profit in Europe and the United States.

Notes on Books.

Polytechnic Series.—Plane and Solid Geometry; by H. J. Spooner. Engineering Workshop Practice; by C. F. Mitchell, and E. G. Davey. Carpentry Workshop Practice; by C. Mitchell. London: Cassell and Co. 1889.

These are the first of a series of manuals specially prepared for the use of students of the Polytechnic Institute by some of the instructors of the Institute. The first volume has been arranged to meet the requirements of the Science and Art Department's examination. The subject is treated in an elementary manner, and with sufficient clearness. A cursory examination reveals the existence of too large a number of misprints, but no doubt these will be set right in a second edition. A chapter on graphic arithmetic forms an important part of the book.

The two other books are intended to help the workshop students in mastering the practice of the two arts dealt with. In the one on engineering he is taught to commence by chipping and filing a square block, simple directions in turning follow, and then instructions for making various simple tools and appliances, such as gauges, callipers, lathe-carriers, &c.

The book on carpentry contains hints on the method of handling the usual carpenter's tools, instructions for making the various joints, for mitreing, mortising, dovetailing, &c. Instructions are given in the method of constructing such tools as a mallet, a marking gauge, straight edges, &c., winding up with a description of the method of making a carpenter's bench.

Both books are very fully and clearly illustrated.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

April 23.—William Whitaker, F.R.S., "Coal in the South-East of England." Archibald Geikie, LL.D., F.R.S., will preside.

April 30.—T. R. Dallmeyer. "Photographic Lenses."

May 7.—Dr. Percy F. Frankland, "The Aim and Scope of Higher Technical Teaching."

May 14.—Dr. J. A. Fleming, "Prof. Elihu Thomson's Electro-Magnetic Induction Experiments."

May 21.—J. G. Gordon, "The Mannesmann Process for making Seamless Tubes."

FOREIGN AND COLONIAL SECTION.

Tuesday afternoons, at Five o'clock:—

April 22.—Sir John Stokes, K.C.B., "The Danube and its Trade." Sir Archibald Alison, Bart., G.C.B., will preside.

May 20.—A. Lasenby Liberty, "The Industrial Arts of Japan."

INDIAN SECTION.

Thursday afternoons, at Five o'clock:—

May 22.—Sir J. Theodore Hope, K.C.S.I., "The Rationale of Indian Railways." The Marquis of Ripon, K.G., will preside.

[The Meetings of this Section have been changed from Fridays to Thursdays.]

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock:—

May 13.—Prof. W. C. Roberts-Austen, F.R.S., "The Use of Alloys in Art Metal-work."

CANTOR LECTURES.

Monday evenings, at Eight o'clock :—

RICHARD BANNISTER, "Sugar, Tea, Coffee, and Cocoa, their Origin, Preparation, and Uses." Four Lectures.

LECTURE I.—APRIL 28.—*Sugar*, what it is—Consumption—History and origin—Sugar of commerce, raw and refined—Analysis and classifaction—Bounties and drawbacks—Specimens of commercial sugars.

LECTURE II.—MAY 5.—*Sugar* used in brewing, distilling, and jam-making. *Coffee*—History—Introduction into Europe—Varieties—Composition of coffee when raw and roasted—French coffee—Coffee substitutes and their detection.

LECTURE III.—MAY 12.—*Tea*—History—East India Company's monopoly—Duties—Adulteration—Tea plant varieties—Composition of tea—Indian and Ceylon tea—Specimens.

LECTURE IV. — MAY 19 — *Cocoa*—History—Origin—Preparation for market and consumption—Composition—Commercial cocoas, nibs, soluble, extracts — Chocolate and chocolate creams — Chart showing consumption of sugar, coffee, tea, and cocoa—Specimens of cocoa, chocolate, and creams.

ADDITIONAL LECTURES.

Thursday evenings, at Eight o'clock :—

LEWIS F. DAY, "Design applied to Wood-Carving." Three Lectures.

May 1, 8, 15.

The regulations for admission will be the same as for the Cantor Lectures, each member having the privilege of admitting a friend.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, APRIL 21...Chemical Industry (London Section) Burlington - house, W., 8 p.m. 1. Dr. Moritz, "The Expulsion of Ammoniacal Compounds from Sulphuric Acid used in Kjeldal Determinations." 2. Mr. Boverton Redwood, "The Petroleum Fields of India."

Medical, 11, Chandos-street, W., 8½ p.m.

Asiatic, 22, Albemarle-street, W., 4 p.m.

Victoria Institute, 7, Adelphi-terrace, W.C., 8 p.m.

TUESDAY, APRIL 22.. SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m. (Foreign and Colonial Section.) Sir John Stokes, "The Danube and its Trade."

Royal Institution, Albemarle-street, W., 3 p.m. The Hon. G. C. Brodrick, "The place of Oxford University in English History." (Lecture II.)

Medical and Chirurgical, 20, Hanover-square, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on Sir Frederick Bramwell's paper, "The Application of Electricity to Welding, Stamping, and other Cognate Purposes."

Statistical, School of Mines, Jermyn-street, S.W., 7¾ p.m.

Anthropological, 3, Hanover-square, W., 8½ p.m. M. Jacques Bertillon, "Anthropometric Identification of Criminals."

Horticultural, Drill-hall, James-street, Victoria-street, S.W., 3 p.m.

WEDNESDAY, APRIL 23...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. William Whitaker, "Coal in the South-East of England."

Botanic, Inner Circle, Regent's-park, N.W., 2 p.m. Exhibition of Spring Flowers.

Sanitary Institute, 74A, Margaret-street, Regent-street, W., 8 p.m. Address by Sir Robert Rawlinson.

Cymmrodorion, 27, Chancery-lane, W.C., 8 p.m. Mr. David Lewis, "The Legal Side of Welsh Social Life in the 15th century."

Inventors' Institute, 27, Chancery-lane, W.C., 8 p.m. 1. Mrs. Helen Monkhouse, "The Excelsior Bed Lift in use at the Westminster, Charing-cross, and Colchester Hospitals." 2. Mr. W. Tupper, "House Refuse Destructor." 3. Various short descriptions of Hospital Nursing Appliances and Domestic Sanitary Inventions.

East India Association, Westminster Town-hall, S.W., 3 p.m. Mr. C. Purdon Clarke, "Is the Preservation of the Industrial Arts of India possible?"

THURSDAY, APRIL 24...Photographic Field Club (at the HOUSE OF THE SOCIETY OF ARTS), 8 p.m. Exhibition of Lantern Slides.

Royal, Burlington-house, W., 4½ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Prof. C. V. Boys, "The Heat of the Moon and Stars." (Lecture II.)

Electrical Engineers, 25, Great George-street, S.W., 8 p.m. Dr. Oliver Lodge, "A Lightning Guard for Telegraph Purposes, and the Protection of Cables from Lightning."

United Service Inst., Whitehall-yard, S.W., 3 p.m. Lieut.-Col. N. L. Walford, "Notes on the Defence of a Modern Fortress."

FRIDAY, APRIL 25...Lantern Society (at the HOUSE OF THE SOCIETY OF ARTS), 8½ p.m. Inaugural Exhibition of Lanrern Slides.

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Sir John Lubbock, "The Shapes of Leaves and Cotyledons."

Civil Engineers, 25, Great George-street, S.W., 7½ p.m. (Students' Meeting.) Mr. C. Frewen Jenkin, "Some Applications of Electricity in Engineering Workshops."

Clinical, 20, Hanover-square, W., 8½ p.m.

Browning, University College, W.C., 8 p.m. 1. Prof. E. Johnson, "Fifine." 2. Mr. J. Abrahams, "Browning's Jews."

SATURDAY, APRIL 26...National Indian Association (at the HOUSE OF THE SOCIETY OF ARTS), 4 p.m. Mr. C. Purdon Clarke, "Indian Art."

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Capt. W. de W. Abney, "Colour and its Chemical Action." (Lecture II.)

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FRIDAY, APRIL 25, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

The Society's *conversazione* is fixed to take place at the Natural History Museum, Cromwell-road, South Kensington (by permission of the Trustees of the British Museum), on Friday, 27th June.

Each member will receive a card for himself, which will not be transferable, and a card for a lady. In addition to this, a limited number of tickets will be sold to members of the Society, or to persons introduced by a member.

Further particulars as to the arrangements will be announced in future numbers of the *Journal.*

Proceedings of the Society.

FOREIGN & COLONIAL SECTION.

Tuesday, April 22, 1890: Sir Archibald Alison, Bart., G.C.B., in the chair.

The paper read was "The Danube and its Trade," by Sir John Stokes, K.C.B.

The paper will be printed in next week's *Journal.*

EIGHTEENTH ORDINARY MEETING.

Wednesday, April 23rd, 1890; Archibald Geikie, LL.D., F.R.S., Director-General of the Geological Survey of the United Kingdom, in the chair.

The following candidates were proposed for election as members of the Society:—

Denison, Samuel, Old Grammar School Foundry, North-street, Leeds.
Leslie, Sir Bradford, K.C.I.E., Tarrangower, Willesden-lane, Brondesbury, N.W.
Kerr, John, 101, Leadenhall-street, E.C.
Pender, Sir John, K.C.M.G., 18, Arlington-street, S.W., and 50, Old Broad-street, E.C.
Stillwell, Lewis B., Westinghouse Electric Company, Pittsburgh, Pa., U.S.A.

The following candidates were balloted for and duly elected members of the Society:—

Barry, John Wolfe, 23, Delahay-street, S.W.
Bateman, James, Pinetown, Natal, South Africa.
Jones, Arthur L., 45, Hillside-road, Stamford-hill, N.
Woollett, Captain William Charles, Royal Dockyard, Woolwich, Kent.
Yardley, Robert Blake, 6, Crown Office-row, Temple, E.C.

The paper read was—

COAL IN THE SOUTH EAST OF ENGLAND.

By W. Whitaker, F.R.S.

To the geologists present I must say that this paper is hardly for them. It is an attempt to explain to men of education, who are more or less innocent of geologic knowledge, an occurrence of great practical importance that has been foretold by geologists. As a rule, neither quotations nor references to authors will be given, a course which may be justified by the fact that those very proper things have been somewhat fully done elsewhere and lately. ("The Geology of London," &c., vol. i., pp. 10–29.)

The science of stratigraphic geology, which deals with the history of the various formations of the earth, and with their relations to each other, began, like other sciences, by observations of isolated facts. Then these facts were compared and their connections seen, with the result that an orderly succession of geologic formations was found to occur in various districts. Then it was inferred that a like connection of facts and a like order of succession would be found to hold elsewhere. Thus geology became a science.

Having now a firm basis for work, geologists were enabled to reason as to the likelihood of what might happen in places where one could not actually see, as at great depths. Perhaps there has been no more striking instance of such reasoning than the foretelling of the existence of an underground range of older rocks at no enormous depth in the South East of England, a tract wherein newer rocks only crop out to the surface. The arguments for this hidden uprise of older rocks, breaking the underground continuity of some of the newer rocks over a large tract, though proved to be right very soon after they had been published in detail, from their technical character were for many years known only to geologists.

For more than thirty years the inferences of some of the leaders of English geology have been slowly justified, by a boring here and a boring there, reaching to old rocks beneath our Cretaceous beds, and the occurrence of old rocks at no enormous distance underground, in and around London, has passed from the domain of inference to that of fact.

Unfortunately, this fact was a somewhat unwelcome one, the rocks found being by no means wanted at the places where they were proved; for they shut out a possible source of deep-seated water-supply, to gain which the borings were made.

The possibility, however, of Coal Measures occurring somewhere amongst these older rocks gave zest to inquiry, and geologists differed greatly in opinion, as they usually do. Whilst some held that not only were Coal Measures likely to occur but also that they were likely to contain beds of coal of workable thickness and at workable depths, others held that such beds were unlikely to occur; and some went further still, inferring that no Coal Measures at all would be found.

The danger of holding a negative theory is well illustrated by this subject, for a single affirmative is fatal, whilst an affirmative view is by no means disproved by a great number of negative results. I have been on the affirmative side, but am far from blaming my brother-hammerers who have held differently: it is only by the conflict of opinions that true views are brought to the front, and the holders of views proved to be wrong may have sometimes done more for the attainment of truth than those who were lucky enough to be right from the first.

The arguments in favour of the probable occurrence of coal at workable depths in the South East of England have been fully, and to my mind, unanswerably brought forward by our leading English geologist, Prestwich, in the Report of the Coal Commission.

We must now get some general notion of the geological structure of the South East of England, as far as regards the formations seen at the surface, but disregarding those various irregular deposits of gravel, brickearth and boulder clay that are massed under the head Drift (and which make up by their wide spread for their general thinness) as well as the more local Crag of the Eastern Counties.

When the succession of geologic formations had been made out in detail, the beds in and around London were found to belong to the lower part of the Tertiary group, as the newest of the three great divisions of stratified rocks was called, and to the upper part of the Secondary group, the part named the Cretaceous Series, from its containing that best known of all British rocks, the Chalk, which comes to the surface near London and is found beneath the Tertiary beds in deep wells.

The various underlying members of the Cretaceous Series were found to rise up and to crop out on the south in the following order from beneath the Chalk, in the tract known as the Weald:—

1. The *Upper Greensand*: a thin sheet of sand and sandstone, the former often decidedly green, the latter generally pale green-grey.

2. The *Gault*: a thicker mass of clay.

3. The *Lower Greensand*: a still thicker mass, chiefly of sands of various colours (other than green) with some limestone or calcareous sandstone in places, and sometimes with a thin middle division of a clayey nature, besides a thin clay base.

4. The *Weald Clay*: to a thickness of some hundreds of feet.

5. The *Hastings Beds*: an assortment of clays and sands of a somewhat varying kind, and also of great thickness. (Grouped with 4 as *Wealden Beds*).

These last come to the surface only along the axis of elevation of the great eroded dome of the Weald, the beds above circling round on the west and south in due order.

The general structure of the South East of England (in section) may be represented graphically in a very simple way, by a gently waved line, with a central crest (the Weald), and a hollow on either side (the London and the Hampshire Basins), the line being from north to south.

If all the five formations noted above had been found to crop out in succession from beneath the Chalk on the north of the London Basin, the natural inference (apart from further considerations that will come in presently) would have been that they all went continously underground from south to north. On the north, however, the Wealden Beds were found to be absent, but the Upper Greensand, the Gault, and the Lower Greensand crop out in due order; and it seemed, therefore, a fair inference that these three formations occurred, beneath the Chalk, under London, and generally under the London Basin, in some such way as shown in the diagram (p. 546), in which allowance has been made for the later discovery of the thinning out of the Upper Greensand eastward, along the northern outcrop. The like thinning on the south does not affect our section, which is taken through London. Naturally, therefore, it was concluded that a deep-seated source of water-supply would be given by the underground extension of the Lower Greensand, and borings to reach that formation were advocated and soon begun.

Before, however, any boring had been made to the depth at which Lower Greensand was expected to be found, Mr. Godwin-Austen had worked out in detail an idea that had been suggested from a general view of the tracts to the west of the London Basin, in Somersetshire, &c., and to the east, in northern France and in Belgium. He showed that there was reason to suspect that, instead of the orderly underground succession of deposits above-noticed, the Lower Cretaceous beds along the slight trough of the London Basin were likely to be interrupted by the rising up of older beds, against the flanks of which some of the Cretaceous beds would be found to thin out.

Before noticing the ground of this argument I may be forgiven for reproducing the first short printed statement of it, a statement made by the earliest official ancestor of our Chairman, Sir H. De la Beche, the first Director General of the Geological Survey, in the first volume of the Memoirs of that Survey. In an essay descriptive of south-western England, after alluding to the possible occurrence of Coal Measures under Jurassic rocks, toward Bath, from the Bristol coal-field, he adds:—"From the movement of the older rocks many a mass of coal measures may be buried beneath the oolites and cretaceous rocks on the east, the remains of a great sheet of these accumulations, connecting the districts we have noticed with those of Central England and of Belgium, rolled about, and partially denuded prior to the deposit of the new red sandstone."

Some years ago Lord Salisbury advised folk to look at a large map, in order to enable them to grasp certain territorial questions. In this matter I agree with his Lordship, and ask you to look at the map on the wall. The figure on p. 547 is simplified and corrected from one given in the report of the Coal Commission, by the help of which you will the more readily follow the reasoning of geologists on the subject of this paper.

It will be seen that, on the east, there is a set of coal-fields, with other rocks older than the Coal Measures, along a curved line, from the neighbourhood of Dortmund and Elberfield, by Aix (or Aachen), Liege, Namur, Charleroi, Valenciennes, Douai, and Bethune, toward Calais, whence the line has now been extended across the narrow sea to Dover, where success has crowned the experiment of Sir E. Watkin and Prof. Dawkins. Again, on the west, we have our own coal-fields of South Wales and of Bristol.

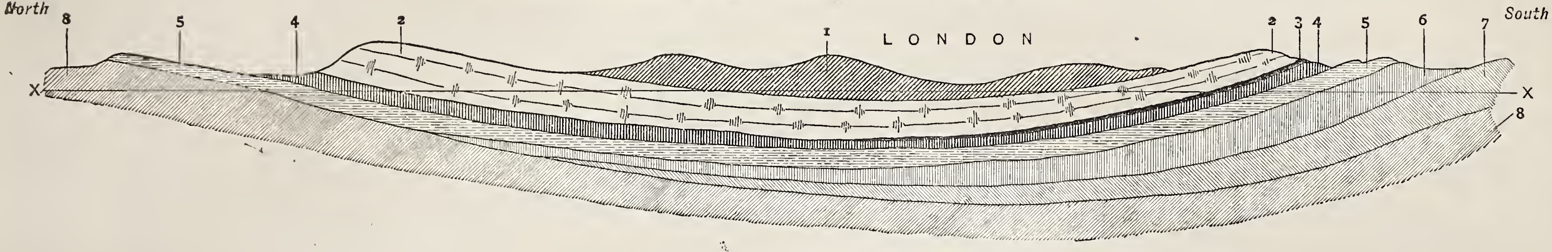
Now, in the continental tract above-mentioned, whilst the Coal Measures are mostly at the surface in the eastern part, in the western they are covered by newer rocks. Why should not the like occur in the English tract, eastward from the part where the Coal Measures are at the surface? What can, on the face of it, be more likely than that the long curve from Dortmund to Dover continues underground westward from the latter place, and, sweeping round, roughly along or parallel to the valleys of the Thames and of the Kennet, ties on our western coal-fields to those of northern France, by a set of basins hidden under newer rocks?

It should be noted that there is a sign, slight though it be, of another possible line of underground Coal Measures, starting on the east from the Saarbruck coal-field, south-west of Mayence, and ending perhaps on the west in the unprofitable Culm Measures of northern Devon and Cornwall. Here we have the ends only, with no evidence between, but these ends both come just south of the ends of the former line. We must hope that our German and French friends will see to this line, and then, if Coal Measures should be found underground in the neighbourhood of Amiens and of Dieppe, we may look for their extension westward into Hampshire and Dorsetshire.

Let us now see how far the theory of an underground uprise of older rocks has been verified by facts, and in the first place by a number of deep borings for water in the London Basin.

Just before the theory was published in detail, the completion of the Kentish-town boring proved the non-existence of the Lower

SECTION ACROSS THE LONDON BASIN. OLD VIEW.

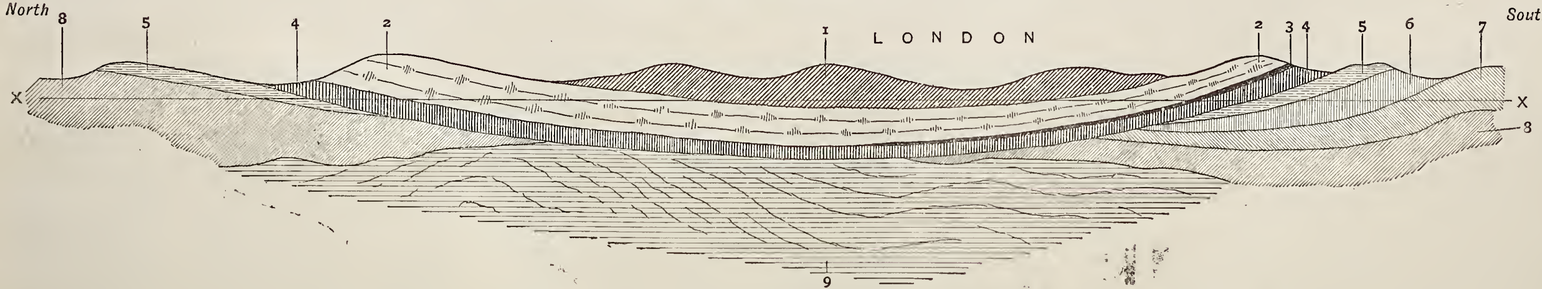


Regularity
- 1. *Tertiary Beds*
- 2. *Chalk*
- 3. *Upper Greensand*
- 4. *Gault*

X *Sea-level*

Irregularity
- 5. *Lower Greensand*
- 6. *Weald Clay*
- 7. *Hastings Beds*
- 8. *Jurassic Beds*

SECTION ACROSS THE LONDON BASIN. NEW VIEW.



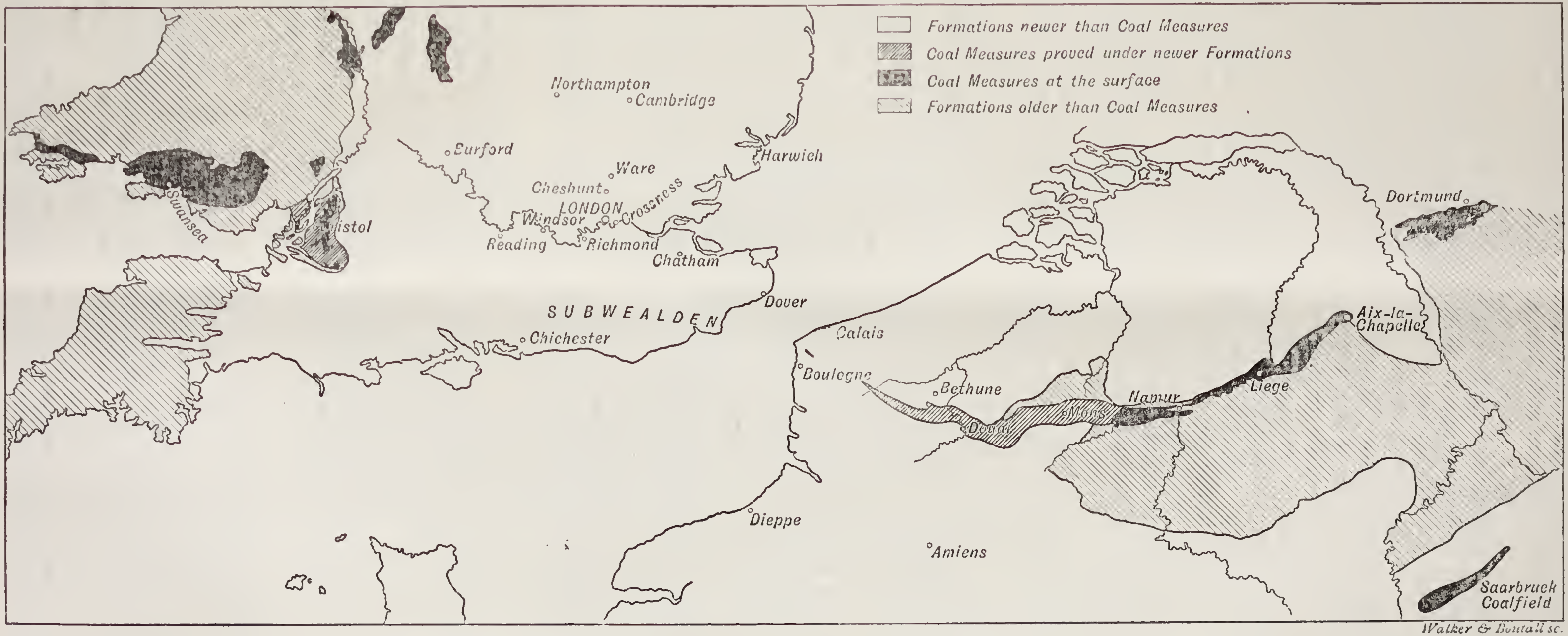
Regularity
- 1. *Tertiary Beds*
- 2. *Chalk*
- 3. *Upper Greensand*
- 4. *Gault*

Irregularity
- 5. *Lower Greensand*
- 6. *Weald Clay*
- 7. *Hastings Beds*
- 8. *Jurassic Beds*

Great Gap
- 9. *Older Rocks*
  Devonian, Silurian,
  perhaps Carboniferous
  ? New Red

SKETCH MAP

OF THE SOUTH OF ENGLAND AND THE NEIGHBOURING PARTS OF FRANCE AND BELGIUM.



Walker & Boutall sc.

Greensand underground in that northern part of London, the Gault being there underlain, at the depth of 1,114 feet, by a set of red and grey beds (clays, sandstones, &c.), which puzzled geologists, and of the age of which, indeed, they are not yet certain: enough here to say that these beds agreed with no Cretaceous or Jurassic beds of this country. So speedy a justification of the theory, between the reading of a paper and its publication, was hardly to be hoped for, even though we were still left in doubt as to what rocks they were which interfered with the ordinary sequence. But this evidence stood alone for a very short time, for in another boring, at Harwich, the Gault was found to rest on a slaty rock of Lower Carboniferous age, at the depth of 1,029 feet.

For about 20 years no further light from facts was thrown on the question, though various opinions were given; but in 1877, a boring at Meux's Brewery, London, passed through the Gault, at the depth of 1,002 feet, into limestone, which has since been shown to be of Lower Jurassic age, though at first taken to be abnormal Lower Greensand; and then, at the depth of 1,066 feet, into shaly rocks, which, from their fossils, were at once known to be of Devonian age, or older than the Carboniferous Series.

The same year a boring at Crossness passed into red beds, like those of Kentish-town, beneath the Gault, at the depth of 1,008 feet.

Soon after, still older rocks than any before found in the district were proved to underlie the Gault at Ware, at which place Silurian beds were reached at the depth of only 797 feet. Almost at the same time Devonian rocks were again found, beneath the Gault, at the depth of 1,081 feet, at Cheshunt.

A few years later the Richmond boring again proved the existence of Lower Jurassic beds (limestones and clays) underneath the Gault, at the depth of 1,152 feet, passing through these, at 1,239 feet, to red and grey clays and sandstones, as at Kentish-town and Crossness, but without clearing up the doubt as to their age.

The next piece of knowledge came from Chatham, where, for the first time, a Middle Jurassic bed (Oxford Clay) was proved under the London Basin, at the depth of 943 feet, but here Lower Greensand was found, though to a thickness of only 41 feet, beneath the Gault. Soon afterward another Government boring in Kent showed that on the northern side of Dover the Lower Greensand was even thinner, and apparently underlain, at the depth of 849 feet, by some of the lower beds of the Wealden Series.

The last of our deep borings for water in the London Basin is at Streatham, where, at the depth of 1,082 feet, Lower Jurassic limestones were found, next beneath the Gault, for the third time, whilst these were passed through at 1,120 feet, and the provoking red and grey beds, about which we can say nothing for certain, were found for the fourth time.

Before passing to other evidence, let us consider some of the points established or suggested by the borings above-noted, points which may be of service in further inquiry.

Firstly.—They show that the Chalk is, for the most part, of fairly regular thickness beneath the Tertiary beds, varying from 623 feet at Streatham, to 685 at Chatham, but that to the north-east it is thicker, to the extent of 890 feet at Harwich. Further northward, indeed, at Norwich, it is much thicker, and we know that it is still more so in the Isle of Wight, to the south.

Secondly.—Omitting the Upper Greensand, as sometimes wanting and nowhere thick, the Gault again is generally not irregular in thickness, varying from 130 feet at Kentish-town to 201 at Richmond. Here too, more distant Harwich is exceptional, but in the reverse way, the Gault being only 61 feet thick there. Southward of London we have evidence, at Caterham, that the Gault is over 300 feet thick. To the base of this clay, therefore, we can count on regularity in occurrence, save in the unimportant matter of the Upper Greensand, and on comparative evenness in thickness.

Thirdly.—Of nine borings that have reached the base of the Cretaceous beds, in four Jurassic beds have been found to occur, whilst in five they are absent, and these latter include all the more northerly borings. It is clear, therefore, that we have now fallen to the level of uncertainty.

Fourthly.—Of the eight borings that have reached rocks older than Jurassic, four have ended in the reddish beds of doubtful age. The settlement of the doubt is not unimportant, for, should the beds prove to be New Red, then there is a chance of Coal Measures occurring beneath them, whereas, if they are Old Red, then Coal Measures are not to be expected unless brought in by a sharp oblique fold, or by an overthrust fault, by means of which older beds have been pushed up obliquely over newer beds, as is the case in parts of northern France, where, in consequence of such a fault, coal is worked beneath Lower Carboniferous or Devonian rocks. A few years ago there seemed to me to be a balance of probability in favour of the New Red, but now I fear that balance has veered round, for some of these red and grey beds at Streatham are more like Old Red, or to the passage-beds from that formation into the underlying Silurian, than to anything else.

Fifthly.—Of the other four borings, one ends in Lower Carboniferous rock, two in Devonian, and one in Silurian, all older than the Coal Measures. As far, therefore, as we know from the borings for water in the London Basin that reach Pre-jurassic rocks, four varieties of rock have been proved by only eight borings, which certainly does not show uniformity but rather variety, leaving open a good chance of other rocks being proved in other places.

Sixthly.—The comparative evenness of the surface of the old rocks underground is remarkable, their depth below Ordnance Datum varying only from 1,222 feet at Richmond, on the south, to 710 at Ware, a long way to the north. It seems, therefore, that these older rocks do not form an underground ridge, but that they have been planed down, in Jurassic and Cretaceous times, until any ridge that may have originally occurred has been levelled down, to as great an extent as the present surface of the country, which is decidedly not mountainous, and to a greater extent if we extend our view to the whole of the chalk-tract.

Seventhly.—Excluding the Harwich boring, which is far from London, the remaining borings that reach older rocks seem to show that London is on one of the cross-uprises, more or less at right angles to the main axis, which probably divide the Carboniferous beds into separate basins. Should any of the doubtful beds turn out to be New Red, or even Carboniferous, this conclusion would not be overthrown, and some of the sandstones are by no means unlike stained Carboniferous sandstone.

Turning to other borings, there are some beyond our district that have a bearing on the question at issue. Thus the proving of Coal Measures, beneath Jurassic and Triassic rocks, at Burford, in Oxfordshire, at the depth of about 1,180 feet, is of interest, and so, also, is the occurrence of Carboniferous and, in one case perhaps, of older rocks in various borings in and near Northampton, at depths of from over 300 to over 500 feet below Ordnance Datum.

But now we may wind up our notice of borings with a short account of the two which have been made purely as search-experiments in the South East of England. The first of these, known as the Subwealden Exploration, was started near Battle, in 1872, and was carried to the depth of 1,905 feet, when it had to be abandoned, in 1876, through accident; its object being to find out what rocks underlie the lowest beds that come to the light of day in that district, and, if possible, to find the depth to some of the older rocks. This boring is sometimes spoken of as a failure, because it did not reach Coal Measures; but this is unfair: the boring was not made for the purpose of finding coal, but for that of gaining knowledge, and in that I venture to say that it was a great success.

The result of the work was to prove the presence of Upper and of Middle Jurassic rocks in great force; for, after passing through 240 feet of Purbeck and Portlandian beds, Kimeridge Clay was pierced to the extent of 1,120 feet, being the greatest thickness of that formation in England, and then 480 feet of Corallian rocks were found before the Oxford Clay was reached, this last being bored into to the depth of 65 feet, and probably going much deeper.

The Subwealden Boring, taken with those in the London Basin already noticed, shows a marked thinning of the Jurassic beds, northward and north-westward from Battle, none of the beds there found occurring in any of the other borings, except at Chatham, where too, the lowest bed of all, the Oxford Clay, alone occurs.

The second and last experimental boring in the South East of England was made for a more limited object; not merely for the general advance of knowledge, but definitely to try whether coal could not be found.

The world was startled one morning in February last by hearing that coal had been found at Dover; but most of those geologists who had studied the subject were by no means surprised, there having been a very general agreement among them that success was as likely to attend a trial in that neighbourhood as anywhere. Unfortunately, the original announcement contained some errors, which crept in, probably, from the gentleman who made it not having a special knowledge of geology. It is most satisfactory that the first and only boring made with the hope of finding coal has succeeded, and that whilst the speculations of geologists on the general subject of the rise of old rocks underground had already been shown to be well-based, so also, in the particular matter of a likely place for the trial for coal, sound deductions had been made.

This boring, which is at the foot of Shakespeare's Cliff, after passing through Lower Chalk, Gault, and Lower Greensand, reached Jurassic beds at the depth of about 500 feet, passed through representatives of the whole of this last great series, from Portlandian to Bathonian, and then reached Coal Measures at the depth of 1,160 feet. On comparing this section, therefore, with that of the Subwealden boring, we see that the Jurassic beds thin north-eastward from Battle, as well as northward and north-westward.

A comparison of the facts proved by the borings that have been described may be easily made from the diagrams of the sections of those borings on the wall, which, with others, have mostly been lent by Professor Judd.

The essential facts of the case being now before us, let us see how these may guide our future work; for it is fair to conclude that so important a subject will not long be left without much further experiment.

Firstly, as regards the beds that will have to be pierced to reach Coal Measures or other old rocks, we have to a great extent a fair amount of certainty; for, in the large tract known as the London Basin, we have no doubt of all the beds from the Gault upward, that is, the Chalk and the Tertiary beds. We are certain of their occurrence, and can make a good estimate of their thickness. Beyond this, however, we can hardly go with safety, except in the immediate neighbourhood of borings that have already given decisive information. In the Wealden tract we have but one very deep boring to guide us, and that as a warning against a particular neighbourhood. In the Hampshire Basin our knowledge reaches only to the base of the Chalk.

Secondly, as to the way in which Coal Measures are likely to occur. Reasoning from what is seen at the surface, to the east and to the west, or has been proved in underground work, we are justified in the following conclusions:—

1. That the uprise of older rocks in Belgium and northern France ties on underground with the like uprise in the West of England.

That as, where this uprise is seen at the surface, or has been continuously proved underground, coal-basins occur at frequent intervals, separated by cross uprises of rocks older than the Coal Measures, so it is to be expected that other coal-basins will be found underground, in the unexplored part of the axis, in like manner separated by older rocks. The method of occurrence of the coal-basins is shown in a long east and west section on the wall, enlarged from one by Professor Prestwich. It should be remembered, moreover, that the proved parts of the axis are together much longer than the unproved part; we know what happens along at least two-thirds of the line, and it is only the other third that is unknown.

2. That, as in the proved parts the Coal Measures contain profitable beds of coal, and at workable depths, we may fairly infer that the like will be found also in the South East of England.

3. That the sites of the coal-basins can only be found by experiment; and that whilst the first experiment, in a neighbourhood specially noticed by geologists as favourable, has been successful, we must not expect such success to be continuous, but must be prepared often to hit on the separating cross-uprises, one of which seems already to have been proved under London, and also sometimes to strike older rocks north and south of the axis of the coal-basins. Negative results are by no means valueless, however.

I may now allude to some of the general principles that should guide us in future search: each particular case must, of course, have its own special consideration. It must be understood that I refer only to the scientific principles, which, alas! are sadly interfered with by others of an unlucky practical nature. It is essential, in costly exploring work, to be sure of a large area over which the explorers may reap the fruits of their labour, instead of finding that their time and money have been spent simply in enriching other folk, who may have done nought to help them. If the national wealth is to be largely increased by the scientific exploration of the South East of England, surely it is not too much to ask that those who carry out the costly work should have a goodly share in the profit thereof; but the laws of this enlightened country make it possible that, after having spent thousands of pounds, used up a good amount of brain-power, and got through much valuable time, explorers may find that they have done little else than increase the property of neighbouring landowners, who have stood by, with their hands in their pockets, until such time as they could practically put the said hands into the pockets of other people —legally!

But here we can deal only with the laws of science, and be guided by them. One such law is to reason from the known to the unknown, and in exploring work a like system holds, and led, to a great extent, to the choice of Dover as a site for trial-work; for the Dover coast is the nearest part to proved Coal Measures on the opposite side of the Strait. This important question of nearness to something known makes all the other borings, that have been described as reaching some of the older rocks, of simply negative value, except, perhaps, in the case of Harwich: their immediate neighbourhood is to be avoided, as they are either directly opposed to the likelihood of getting coal, or leave the chance of so doing very doubtful.

Besides the topographical aspect of nearness, there is, however, another that may be profitably thought of, namely, the continuation of certain borings that are already a long way down, and that seem to promise a valuable result. Amongst such, that at Chatham may be particularly noted: it has already reached the Oxford Clay, and, judging by the northerly thinning of the Jurassic rocks (from the Weald), some decisive result is to be expected there from a few hundred feet of further work. The boring, too, belongs to Government, and the deepening of it would, in case coal were found, be of profit to the nation rather than to any private person. Perhaps a scheme for exploration in the London Basin that was started before the Dover boring was known may take up this as its first work, unless Government can be moved to make the experiment, as would probably happen in other countries.

Another likely site, for the continuation of work already done, is St. Margaret's, northeastward of Dover, where a boring, made for the former Channel Tunnel Company, has reached the Gault, and where probably less of the Jurassic rocks would be found than at the Dover boring, though the two are not five miles apart.

Another point of importance in choosing a site for trial is to keep in view the advantage of having as little as possible of overlying rocks to get through before reaching a depth at which something decisive, whether yea or nay, may be expected. At first sight, this seems to mean simply starting as low down geologically as one can; but a little reflection on what has gone before will show that the question is not one of such simplicity. Of all the borings described, the Subwealden one, which is the deepest, has far and away the best site, on the above simple view; but, with a depth of over 1,900 feet, it fails to do more than get into Oxford Clay, and it tells us no more as to the position of the older rocks (and probably much less) than does the boring at Chatham, in very little more than half that depth. Yet the former begins just below the thick Wealden Series, whilst the latter starts far higher in the geologic scale, at the base of the Tertiary beds. The reason of this is that the Lower Cretaceous (including the Wealden) beds, and the great Jurassic Series, thicken vastly southward, from the Valley of the Thames (where, indeed, they are sometimes absent), so that, in going south, the thickening of these lower beds more than makes up for the loss of higher beds (Gault, Chalk, &c.) from erosion at the surface, as may be seen from one of the sections on the wall. Of course, borings in the Weald, or in any other area, are still subject to the advisability of beginning at a low geologic level, and it should be enforced that the failure of one boring in the Weald to reach old rocks by no means justifies the inference that in other parts of that large tract success may not crown work.

Another obvious advantage is to begin at as low a level as possible. There is no need to start on a hill when Nature has kindly provided a valley near by and so lessened our work.

Geologists are always ready to use work done by labourers in other branches of science, and of late a most interesting work has been going on, which beautifully shows the bearing that one branch of knowledge may have on another. Professors Rücker and Thorpe have been carefully noting the behaviour of the magnetic needle in various parts of the kingdom, and they have found that it often misbehaves, a result not unusual in research, either as regards instruments or people: it was deflected in many places from what would have been thought to be its proper direction. The explanation of this was, of course, to throw the blame from the needle to the surroundings, and to charge the deflection to great masses of basaltic, or like rocks, the minerals of which contain a large amount of iron. Finding, however, that this peculiar behaviour of the magnetic needle occurred also in tracts where no such rocks were at the surface, but which consisted of such formation as Chalk and Tertiary beds, these observers were led to conclude that deep underground in those tracts there was a mass of basaltic or other highly ferruginous rock that affected the needle; indeed, at first sight no other explanation occurs.

Professor Rücker (who has kindly revised this short statement) tells me that one such tract, in the South of England, was very fully investigated. The compass-needle is drawn to a line which runs along the Valley of the Thames to Reading, and passes thence to South Wales, and possibly even to the South of Ireland. The most powerful effect was observed between Reading and Windsor, and from this neighbourhood secondary lines of disturbance radiate through Hertfordshire toward Cambridge, through Oxfordshire toward Kenilworth, and southward to Chichester. Of these three the last is the most clearly marked, Chichester itself being near a well-developed centre of attraction.

Now the Reading and Windsor district is on the first of the geologic lines (if one may so call them) traced above, from Dortmund to South Wales, and the Chichester tract is along the second suggested geologic line, from Mayence to North Devon: it would seem, therefore, that the two tracts are on one of those north and south cross-lines of uprise that bring up rocks older than the Coal Measures.

You have probably all heard of the divining rod, a simple forked twig, the skilful use of which enables a man in Cornwall to find metalliferous minerals, whilst in other districts the operator spots underground water in absolutely the same way, a topographical peculiarity that has not yet been explained. Although Professor Rücker's elaborate and scientific divining rod is by no means equal to the dowser's twig, it seems possible that it may tell us what places to avoid in searching for Coal Measures underground; it will perhaps give advice like that of *Punch*, "To those about to marry—Don't."

In concluding this part of the subject, I should like to allude to a matter of detail. All the deep exploration above-noticed, whether for water or otherwise, has been made by boring: it would be satisfactory if we could have some shaft-sinking, at all events in places where there is little to fear from water. The beds that have to be pierced are not hard, but of a kind easy to sink through, and though the expense of sinking would be greater than that of boring, yet the advantages of the former process might make up for this. It is always open to any disciple of St. Thomas to cast a doubt on what has been brought up from a bore-hole, on the ground that it may have been dropped down beforehand. Probably many of you know the story of the trial-boring from which coal was brought up one day, but only to be followed by bread and cheese the next day; a succession quite out of the geologic sequence of formations, and not to be explained away by any disturbance of the beds, even an overthrust fault. Now, with a shaft, if anyone doubts the occurrence of coal, he can be taken down to see for himself, with perhaps the further advantage that, if his doubts still last, he can be left down for reflection.

Moreover, in case of success, a shaft comes in for working-purposes, whilst a boring is useless. Another advantage of a shaft is that it gives the power at any time of exploring horizontally, by means of galleries, in any direction, should such a course be advisable; whilst with a boring one can only go vertically down. Supposing, for instance, that the deepening of the Dover boring should show that the Coal Measures are there of little thickness, the boring will give no sign of the direction in which thickening is to be expected, and all further information will have to be got from fresh work, from the very top. With a shaft however, it is most likely that horizontal working would give the information needed. I have heard, indeed, of a case where great success followed such work, but not until after galleries had been driven in three directions.

Without wishing to touch on a subject so provocative of discussion as the Channel Tunnel is, I cannot but say that it would be useful if Sir E. Watkin's well-known weakness for tunnelling could be turned, for a time at least, from a horizontal to a vertical direction, so that a shaft might be at once sunk at Dover.

Having put the scientific view of the question, and, I hope, the practical one, before you, the sentimental view must be noticed. One is often met by remarks to the effect that it is to be hoped that coal will *not* be found in the South-East of England, the ground for the hope being that many beautiful tracts of country would be spoilt by the workings for coal. I must say that this notion seems to me of a selfish kind, and, one may say, also unpatriotic;

it is a preference for our own personal pleasure above the good of our country at large.

For my own part, whilst no one can value more than I do the lovely scenery of parts of Kent and of Surrey, besides the less-known beauties of our flatter Eastern Counties, yet to put them in the balance with the increase of the chief source of our national wealth, with the means of advancing or of sustaining the prosperity of England, seems to me shortsighted indeed.

But is there not some needless alarm in this matter? Is it in the least likely that the whole country in question will be dotted all over with collieries, and that, instead of blue sky, nothing will be seen but black smoke? It is only where coal is found within easy reach of the surface that colliery-shafts are near together; where coal is won at great depths, the sinking of the large shafts needed is a costly work, and one, therefore, not to be rashly repeated. Moreover, it seems likely that the prettiest tracts of country are not in those parts where work is likely to be undertaken; they are, as a rule, at high levels, where shafts would not be sunk and collieries would not be set up.

It must be allowed, too, that there are many districts in the South East of England where there is not much in the way of scenery to spoil. Thus the Weald Clay area is of no great scenic value, and it is certainly not specially suitable for residential purposes. The same may be said of the broad area taken up by the London Clay in south-eastern Essex; indeed, one can think of few tracts that might be handed over to the spoiler with greater calmness of mind than this latter, bordering which, indeed, are parts that might actually be improved by the establishment of collieries. Surely it would not be a very bad work to bring up the levels of the great alluvial flats of Foulness and the neighbourhood to something above high-water-mark, and to save the dwellers in those benighted places from trusting their safety from floods to an earthen wall. Perhaps, too, a judicious admixture of London sewage with the refuse from collieries, should such luckily be established there, might produce a fertile soil, and help in solving our great sewage-problem.

We must remember, moreover, that the damage done to the surface of a country by collieries is not everlasting: on the cessation of working the land reverts, more or less, to its earlier state, and a mining tract again becomes rural. I have seen verdant meadows where coal had been worked some fifty years before, and a fine park where the like had happened still longer ago. From this point of view we should also remember that if some of our lovely southern scenery should be affected by the working of coal, on the other hand equally fine country elsewhere will be redeemed as its coal is worked out. We must look, too, to improved methods of work resulting in less defacement of country.

To sum up the case. The geologic structure of a large tract of country points to the existence, in the South East of England, of hidden coal-fields, lying in the folds of rocks older than the Coal Measures, or coming in against the flanks of such older rocks.

The position of these underground stores of fuel cannot be known without trial-work, perhaps of great extent, and in which failure must be expected to alternate with success. Exploration has to be carried northward and southward, as well as from east to west, over a large area, and, as yet, we are able to make only approximations to the line or lines along which Coal Measures are likely to occur.

The finding of these coal-fields will add greatly to the national wealth, giving us a supply of coal that may make up for the falling yield of some of our well-worked fields. Other mineral riches, too, may reward our search.

It may be, indeed, that the coal-supply of the future will be largely derived from the South East of England, and some day it may happen, from the exhaustion of our northern coal-fields, that we in the south may be able successfully to perform a task now proverbially unprofitable—*We may carry coal to Newcastle.*

The subject will be treated more technically, especially from a coal-mining standpoint, and with reference to the coal-fields of northern France, by Mr. Topley, in a paper, "On Coal in Kent," which is to be read to the Federated Institution of Mining Engineers, at the Institution of Civil Engineers, London, on Wednesday, April 30, at 1.30 p.m.

On Friday, June 6, Professor Dawkins will also discourse on the subject at the Royal Institution, especially with reference to the Dover boring.

DISCUSSION.

Mr. W. Topley, F.R.S., said he would refer only to one or two special points, it being quite unnecessary to add anything on the general questions. With regard to the Sub-Wealden boring, he would enforce what had been said, that it was never undertaken with the view of finding coal, but with the object of reaching the palæozoic rocks and a depth of 2,000 feet. If the object had been to get coal, such a spot would never have been chosen. Nothing was known of the underground structure of the country, but if they had wanted to bore where the strata were thought to be thin they would not have gone to Sussex. The fact was the enterprise was got up by Mr. Willett as a memorial to the British Association when it met at Brighton, and that to a large extent determined the position of the boring. They did not quite succeed in getting down 2,000 feet, but they proved the succession of the beds, and the knowledge thus gained was of immense advantage in pointing out what spots to avoid in future. Another point of great importance was the similarity of the strata in the West of England and in the west of Europe. He had lately had an opportunity of seeing the Bristol coal-field, and then, in company with Boyd Professor Dawkins, visiting the Boulonnais, and examining the way in which the coal lay underneath the secondary rocks in both districts. As long ago as 1822, Buckland and Conybeare pointed out this similarity in a paper before the Geological Society, but it extended to much more minute detail than was then supposed. The succession of the beds, the nature and comparative thinness of the seams, and their number, all corresponded, as did the general structure of the coal-fields. In both places they found overthrust-faults where the older beds were thrust over the newer, generally from north to south, so that in the Belgian coal-field a large amount of coal was got from below the carboniferous limestone. In the Boulonnais the coal had been worked for about 200 years, and the larger part had been got from beneath the carboniferous limestone; this was hardly the case anywhere in England except in the Bristol coal-field, and there not so largely as in the French and Belgian. One or two cases were worked out years ago by Mr. McMurtrie, and in the Radstock area two or three years ago by Mr. Handel Cossham, whose sudden death that day they must all deplore. The north-west coal-field of France seemed to point straight to Dover, and although it looked small and unimportant on the map, it was really one of the most important in France. It was only in the year 1864 that coal was worked in the Pas de Calais, but now the third of the coal raised, and one-fourth of that consumed in France, came from that small area. There was nothing to show that the prolongation of that coal-field in the South East of England might not be equally important. It was quite possible, of course, that there might be the same overthrusts and faults, but this point had a double significance. Up to 1870 or 1872 all the borings in the Pas de Calais put down to the Carboniferous Limestone were supposed to be barren, but in 1872 it was proved that coal occurred underneath, and since that time a large quantity of the coal in that district had come from such a position. It was the same in the Boulonnais, and might be the same in England. Many borings would be necessary to show the range and structure of the coal-field, but it might be taken as certain that we should not long lag behind our continental neighbours, for though we had not the same advantages from a legal point of view, some means would be found to thoroughly work out the problem.

Prof. RÜCKER, F.R.S., said he was not prepared to discuss the question from the geological point of view, but the task that he and Professor Thorpe had undertaken had shown hitherto unsuspected relations between the magnetic properties and geological characters of various districts. It was an undoubted fact that there was magnetic attraction along certain definite lines which ran across the country, one from the Wash to the line of the Midland Railway, between Hawes and Settle, a distance of 150 miles, and they had traced it to within five miles. The line across the South of England, which had more special reference to the subject of the paper, had not been traced in the same detail, except in the neighbourhood of London, but they could say with confidence that a line from somewhere near the south of the Thames, running across to Wexford, and through the South Wales coal-field, was a line to which the magnet was attracted, especially near Reading. Two theories had been put forward to account for the phenomena. One that there were magnetic rocks, magnetised either inherently or by induction in the earth's magnetic field, the other that there were electric currents which flowed through the surface of the earth, which were governed in their intensity by the geological characteristics of the district, in one place flowing through rocks of high conductivity, and in others through rocks of less conductivity. It was thus conceivable that the nature of the rocks might cause the deflection of the needle either directly or indirectly, and they had been endeavouring to decide which theory was correct. They had taken districts, notably one in Reading and another in Lincolnshire, where there was a large magnetic division, and Mr. Preece had been kind enough to carry out electric surveys of the same districts, and map the earth currents, and the result was that no relation whatever was found between the direction and intensity of the earth currents and the direction in which the needle pointed. Commander Creak also had found that in the northern hemisphere islands attracted the north pole of the needle, whilst in the southern hemisphere, when there was magnetic attraction by islands, it was the southern end of the needle which was attracted. This could only be explained, if electric currents were the cause, by supposing that the currents circulated round the islands in one direction in the northern hemisphere, and in the contrary direction in the south. He would not say that it was impossible to conceive of any physical explanation of such a fact, but none occurred to him, and it seemed much more easy to suppose that the rocks of which the islands were composed were magnetised by the earth's magnetic field, as a poker would be, and that thus the upper ends of them were positively magnetised in each case. On the whole, therefore, he leant to the view that the needle was affected by the direct magnetic properties of the rock. If so, this would only happen where iron occurred in considerable quantity. But these rocks were probably at far greater depth than any to which Mr. Whitaker had referred. Considerable effect might be produced by rocks 6,000 or 7,000 feet beneath the surface. Possibly, therefore, the underlying older igneous rocks, which were inferior to all the strata which had been mentioned, might nevertheless to a certain extent govern the form of the overlying strata, and where there were folds in the older rocks, the strata above might follow them. Thus, where the old rocks came nearer the surface, still older magnetic rocks might follow them, and affect the needle. He should like to know if any specimens of the old red rocks were available for magnetic investigation. At present he was engaged in examining the magnetic properties of various rocks, and should like to ascertain whether those had any properties which would account for the phenomena observed. There were two or three remarkable coincidences between geological and magnetic fields in the South of England. Between Bristol and South Wales the older rocks came to the surface. At present they only had four stations in that neighbourhood—at Brecon, Gloucester, Cardiff, and Clifton—and at all four the needle was drawn towards the patch of old rocks which lay between the two coal-fields. Hence, if his view were correct, the older rocks came nearer the surface, and the needle indicated the place where coal should not be expected. Then, coming to Reading, sixty miles further east, the needle again showed a marked attraction to a definite point, and the supposition was that under the surface the same thing occurred as sixty miles to the west. One other point which had not been referred to in public, and of which he had only seen the full bearing on hearing the paper was this. They had stations at Dover, St. Leonards, and Tunbridge-wells; now, from what Mr. Whitaker said, it was clear that at St. Leonards there was a much greater thickness of Tertiary strata between the surface and the underlying rocks than at Dover. Where the underlying magnetic rocks came near the surface, they would expect the downward pull on the needle to be very great; and, on the other hand, where they were far from the surface, the vertical force would be comparatively small. Now, both at Tunbridge-wells and at St. Leonards, where there was a great thickness of the upper strata, the vertical force was small; but at Dover, where apparently the lower strata came nearer the surface, the vertical force was greater; and in a magnetic map which had been communicated to the Royal Society they showed Tunbridge-wells and St. Leonards as lying in a region of low vertical force, whilst Dover was in a region comparatively high. It appeared, therefore, that there was a general agreement between geological and magnetic phenomena which was well worth following out.

Professor McKenny Hughes, F.R.S., said there were one or two important points which would have to be considered in making these investigations. One was, how to find out what was the direction of the dip in boring. The diamond borer, by its rotation, cuts an annular space, leaving a column of solid rock in the middle, attached at the bottom; and to get that out the borer was withdrawn and another instrument put down which clutched it and brought it up in pieces; but this required a considerable wrench, and when you got it up you could not tell that the direction of the strata was the same as it was at the bottom of the bore-hole. There was a strong committee, including Sir William Thomson, Clerk Maxwell, Darwin, Siemens, Stokes, and others, organised to deal with this question in connection with the boring at Ware; one suggestion was to send down a compass-needle to the bottom, and then pour something sticky on the top to keep it in position; another was to smash it so that it could not turn, and then bring it up, but Sir William Thomson advised trying a simpler method first. He said the difficulty arose from the torsion of the rods when trying to wrench up a great mass, but if a smaller rod was sent down first to make a mark upon or take an impression of the top of the core, they would be able to identify the position in which it lay when it was brought up, however much it had shifted in the process. That plan proved successful, and in that way the direction of the dip at Ware was ascertained. At Turnford it was not so successful, however. There were many points connected with the distribution of rocks which had yet to be worked out; one marked feature was the curious way in which the beds seemed to turn round at a certain point and alter their direction, and therefore in dealing with the older rocks, whose sequence they were endeavouring to ascertain, it would be well to study their behaviour in places where they were more easily accessible. At Harwich the rocks were higher than the Silurian or Devonian, but in neighbouring districts these were soon arrived at. If along the east coast the lower Carboniferous strata were found, just outside that range you may expect to find the higher Carboniferous; and there was another reason, therefore, for expecting to find coal in that area. They knew there were higher ridges elsewhere, but they were not anticlinal folds, but many of them were left by denudation. The synclinal folds were later than some of those they were inquiring into, in seeking for the basins in which the Coal measures had been dropped. The more southern line which had been referred to might be a different thing, and not connected with Saarbruck, but to the Belgian coal-field. It was a question for scientific investigation first, before the public were asked to put their money into a shaft. The whole country ought to be mapped out scientifically. In the Bristol Channel there was an anticlinal, the tops of the ridges were not the tops of the folds. Snowdon was not a hill with beds rising up from the plain; it was really in a trough, and that in fact was often the case in denudation, the infolded portion being left. The question needed all possible knowledge brought to bear upon it, and the light which was thrown by experiments in magnetism, as well as by geologists, showed that it was not to be undertaken simply by a commercial man, who put so much in, and got up a company, and got out again as soon as he could when he found it had been started in the wrong place. Science must come first, and then business.

The CHAIRMAN thought everyone present must share his feeling of surprise and pleasure at finding that a number of geologists could come together and discuss a question like this with so little difference of opinion, and it might be taken as strong evidence that on this particular question there was really nothing to fight about. He knew of no recent instance where a true scientific induction had been followed with such brilliant success as the one now brought forward. It had been discussed more or less academically by geologists for some sixty years, bit by bit evidence had accumulated as they went further and further below the surface, and at last it had been definitely proved that coal existed in the South East of England. An ordinary observer would have found it almost impossible to imagine, when standing on a sunny day in the south of Kent, that coal was to be found there hundreds of miles from the great coal-fields, and it would be difficult to make such a person understand why geologists should pitch upon such a spot as a likely place for a colliery. Mr. Whitaker had gone over the evidence, and every one must have realised how the conclusion had been arrived at, and how admirably the inference had been proved by experiment. But, as Professor Hughes had said, they were very far from having reached a complete picture of the geography of the rocks that underlie the Secondary rocks of the South-East of England. They were groping their way by degrees, and in the process coal had been discovered. He did not imagine there could be any large continuous coal-field there; it could only exist in detached basins (even allowing for overthrusts), separated by uprises of older rocks. Further to the west they knew nothing by actual borings, and in no other way could anything like a map of the subterranean geology be obtained. It might be surmised with some probability that, between Bristol and the areas where borings had been made, there might be more extensive coal-fields than were at all likely to be found in the extreme south-east. They had heard of the wonderful plication of the Carboniferous strata in the west of France, but it must be remembered that not only had the Coal Measures undergone these movements, but the Secondary rocks which overlay them had also been crushed, folded, and pushed over each other in the manner which any one might see on the south coast of Dorsetshire; and this process must have considerably thickened the Secondary rocks, the consequence of which was that you might bore through the same stratum sometimes a very long way. It was absolutely necessary that, in the prosecution of this matter, the practical man should go hand in hand with the man of science, otherwise a great deal of time, money, and labour would be wasted.

Mr. WHITAKER said he quite shared with the Chairman his astonishment at the wonderful unanimity of geologists on that occasion. He had been very glad to hear Professor Rücker's observations, and it was very satisfactory to find that he had extended his researches to a depth of 6,000 feet, while geologists had only been able to go something short of 2,000. He hoped Professor Rücker would be able to continue his valuable researches in a thorough manner over a large portion of the south of England. He did not agree altogether with Professor Hughes's account of the mode of boring. At Streatham, where he saw the operations going on, the whole thing came up broken off in the diamond boring tool, without having to withdraw it and put down a clutch, and he believed that was how it was now done. In spite of Sir W. Thomson and all the other scientific men, he still had a little doubt about the direction of the dip; it was more likely to be south than anything else, but he did not feel very certain about it. Professor Hughes had very properly remarked that the hills of the present day were not exactly the hills of the geologist. As a general rule, the hills in the southern counties were in a geological trough, and this was easily explained. When beds dipped inward they could not tumble in, but when they formed an arch they tumbled out and were eroded. Professor Hughes's remarks enforced what he had said about the advantage of sinking a shaft; you could then find the dip without difficulty. As the Chairman had said, you might bore a long way through the same bed, as had happened at Wickham in Essex. The boring after passing through the London clay, and the beds underlying it, went again into the London clay and the underlying beds before it got to the chalk. There was a most complex arrangement of folded beds, and it was evident there had been some great disturbance which had pushed the newer beds underneath the older ones. It was on a line along which geologists for other reasons had expected to find some disturbance, and it was proved most conclusively. Economically it would not pay to experiment with borings to a greater depth beneath the older rocks on the chance of finding overthrust faults. Such deposits would be found afterwards by the extension of workings from the better known areas; and he doubted whether any large quantity of coal would be found in such positions, though possibly it might. He had been much grieved to hear of the death of Mr. Cossham, who was a good geologist, and it was a great loss that one of the few scientific members of the House of Commons should have passed away.

The CHAIRMAN then proposed a vote of thanks to Mr. Whitaker, which was carried unanimously, and the proceedings terminated.

Miscellaneous.

RAILWAY CONSTRUCTION IN JAPAN.

Her Majesty's Consul at Yokohama in his last report says that the extension of railway communication during the last year or two forms perhaps the most important feature of the material development of that part of Japan lying to the east of the Biwa Lake. The following sections of the main line, destined at an early date to connect Tokio and Yokohama on the one hand, with Kaoto, Ozaka, and Kobe on the other, are now open for traffic:—Tokio Yokohama section, 18 miles; Yokohama Kodzu, 31 miles; Kodzu-Shizuoka, 71 miles; and Hamamatsu-Ofu, 56 miles. The section between Shizuoka and Hamamatsu, about 47 miles in length, although under construction, is still practically completed, and the opening of it to traffic is not likely to be much longer delayed. Ofu is the junction where the trunk line of the Tokaido route forms the connection with the Taketoyo-Tsuruga section passing by Gifu, Ogaki, and Nagabama on the Biwa Lake. The Taketoyo-Tsuruga section consists of 102 miles. This gives a total of 278 miles now open to traffic on this system. From Tokio, stretching overland towards the north west coast, there is the Shinagawa-Maebashi, 75 miles, and the Ueno-Akabane sections, 6 miles of the Japan Railway Company; and from Takasaki on the former, the section of the Government railway thence to Yokogawa, at the foot of the Usui Pass, 18 miles, and from Karnizawa above the pass, the section thence to Naöetsu, on the west coast, 92 miles. This leaves only the gap at the Usui Pass to complete the connection with the province of Echigo and the north-west coast. At present the connection is effected by means of a tramway, or portable railway of about eight miles in length. This is taken advantage of for passenger traffic, but goods traffic is carried on in ordinary carts. From Omiya on their line to Marbashi the section of the Japan Railway Company towards the north branches off. This is open as far as Shiogama near Sendai, 208 miles. The remaining private lines open to traffic are the Oyama Kiryu section of the Ryo-mo Railway Company, 33 miles, and the Mito Railway, from Oyama to Mito, 42 miles. This gives a total of 388 miles of Government railways in this part of Japan now actually open to traffic, and 364 miles of private lines, more or less under Government direction, or 752 miles in all. There are at present under construction the following sections:—Of the Government railways, the branch leading from the main line at Ofuna to Yokosuka, 11 miles, the Shiznoka-Hamamatsu section above referred to, 47 miles, and the section of 43 miles along the eastern shore of Lake Biwa, the opening of which to traffic in the course of this year will complete the through rail connection with Kyoto. The following sections of private railways are also under construction:—The Japan Railway Company's section from Sendai to Aömori, 240 miles; the Ryomo Railway section from Kiryu to Marbashi, 19 miles; the Kansei Company's line in Isé, 72 miles; the Kobu Railway Company's line from Tokio to Hachoji, 23 miles; making in all 455 miles. All of these sections, with the exception of the Sendai-Aömora section and the Kansei railway, will, it is expected, be open to traffic this year. The following projected lines have recently been surveyed:—The Nikko Railway from Utsunomiya to Nikko, 21 miles; the Koshu Rail from Gotemba to Matsumoto, 117 miles; the Yamagata Railway from Oishida to Yamagata and thence to Shiroishi, 78 miles; making in all 216 miles of railway. This, together with the 455 miles under construction, and the 752 miles open to traffic, gives a total in the part of the mainland in Japan to the east of the Biwa Lake of 1,423 miles of railway either in operation or in various stages of progress.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

APRIL 30.—T. R. DALLMEYER. "Photographic Lenses." CAPTAIN W. DE W. ABNEY, C.B., F.R.S., will preside.

MAY 7.—DR. PERCY F. FRANKLAND, "The Aim and Scope of Higher Technical Teaching."

MAY 14.—Dr. J. A. FLEMING, "Prof. Elihu Thomson's Electro-Magnetic Induction Experiments."

MAY 21.—J. G. GORDON, "The Mannesmann Process for making Seamless Tubes." SIR FREDERICK BRAMWELL, Bart., D.C.L., F.R.S., will preside.

FOREIGN AND COLONIAL SECTION.

Tuesday afternoons, at Five o'clock:—

MAY 20.—A. LASENBY LIBERTY, "The Industrial Arts of Japan."

INDIAN SECTION.

Thursday afternoons, at Five o'clock:—

MAY 22.—SIR J. THEODORE HOPE, K.C.S.I., "The Rationale of Indian Railways." The MARQUIS OF RIPON, K.G., will preside.

[The Meetings of this Section have been changed from Fridays to Thursdays.

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock:—

MAY 13.—Prof. W. C. ROBERTS-AUSTEN, F.R.S., "The Use of Alloys in Art Metal-work."

CANTOR LECTURES.

Monday evenings, at Eight o'clock:—

RICHARD BANNISTER, "Sugar, Tea, Coffee, and Cocoa, their Origin, Preparation, and Uses." Four Lectures.

LECTURE I.—APRIL 28.—*Sugar*, what it is—Consumption—History and origin—Sugar of commerce, raw and refined—Analysis and classifaction—Bounties and drawbacks—Specimens of commercial sugars.

ADDITIONAL LECTURES.

Thursday evenings, at Eight o'clock:—

LEWIS F. DAY, "Design applied to Wood-Carving." Three Lectures.

LECTURE I.—MAY 1.—Design and draughtsmanship—How carving comes about and what it does—The rudiments of design and its development—Line and mass—The relation of the later forms of design to the earliest, with parallel examples—The distribution of design—System—Reticence in the use of ornament—An instance of—How to set about design—Composition—Simplicity and directness of purpose.

LECTURE II.—MAY 8.—Carpentry, joinery, and the ruder forms of carving connected with them—Effective carving—Gothic and Elizabethan design—Geometric forms—Design in reference to high and low relief—Undercutting—The relation of the carving and its design to the wood—The rendering of natural forms—The treatment of the ground—Pierced work—Handling.

LECTURE III.—MAY 15.—The circumstances controlling design—Its application to specific purposes—Panels, pilasters, columns, caps, friezes, mouldings—Style and the styles—The Transitional period—François 1er, &c.—The Renaissance—Arabesque and grotesque, cartouches, strapwork, wreaths, &c., their use and abuse—The florid design of a later period—The French styles—Practical hints on the study of style.

The regulations for admission will be the same as for the Cantor Lectures, each member having the privilege of admitting a friend.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, APRIL 28...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Richard Bannister, "Sugar, Tea, Coffee, and Cocoa, their Origin, Preparation, and Uses."

Actuaries, The Quadrangle, King's College, W.C., 7 p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

TUESDAY, APRIL 29...Bath and West of England Society (at the HOUSE OF THE SOCIETY OF ARTS), 10½ a.m. Conference.

Royal Institution, Albemarle-street, W., 3 p.m. The Hon. G. C. Brodrick, "The place of Oxford University in English History." (Lecture III.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Discussion on Sir Frederick Bramwell's paper, "The Application of Electricity to Welding, Stamping, and other Cognate Purposes." 2. Mr. John Robinson, "The Barry Dock Works."

WEDNESDAY, APRIL 30...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. T. R. Dallmeyer, "Photographic Lenses."

Geological, Burlington-house, W., 8 p.m.

Microscopical, 20, Hanover-square, 8 p.m. *Conversazione.*

Royal Society of Literature, 21, Delahay-street, S.W., 4½ p m. Annual meeting.

THURSDAY, MAY 1 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Additional Lectures.) Mr. Lewis Foreman Day, "Design applied to Wood-carving."

Royal, Burlington-house, W., p.m. 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Prof. W. Fream, "Quantitative Examination of Water-meadow Herbage." 2. Mr. R. J. Pocock, "Some Old World Species of Scorpion."

Chemical, Burlington-house, W., 8 p.m.

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Mr. Phil. R. Morris, "Impressionism, Realism, and Philistinism."

Royal Institution, Albemarle-street, W., 1½ p.m. Annual Meeting. 3 p.m. Prof. C. V. Boys, "The Heat of the Moon and Stars." (Lecture III.)

Mechanical Engineers, 25, Great George-street, W.C., 7½ p.m. 1. Inaugural Address by the President. 2. Professor Alexander B. W. Kennedy, "Research Committee on Marine-Engine Trials: Report upon Trials of three Steamers, *Fusi Yama*, *Colchester*, *Tartar*."

Archæological Institution, Oxford-mansions, Oxford-street, W., 4 p.m.

FRIDAY, MAY 2...National Home Reading Union (at the HOUSE OF THE SOCIETY OF ARTS), 2½ p.m.

United Service Inst., Whitehall-yard, S.W., 3 p.m. Colonel Frank Graves, "Cavalry Equipment, Organisation, and Distribution."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Mr. W. H. Pollock, "Theophile Gautier."

Mechanical Engineers, 25, Great George-street, S.W., 7½ p.m. Discussion on Prof. Kennedy's "Report on Marine Engine Trials."

Geologists' Association, University College, W.C., 8 p.m. 1. Major-Gen. C. A. McMahon, "The Manufacture of Serpentine in Nature's Laboratory." 2. Prof. G. S. Boulger, "A New Species of Capulus." 3. Mr. T. P. Moody, "Note on the Occurrence of Amberite (Retinite), or Fossil Gum, in a seam of coal at Kawa-Kawa Colliery, Bay of Islands, New Zealand."

Quekett Microscopical Club, 20, Hanover-square, W., 8 p.m.

Physical, Science Schools, South Kensington, S.W., 5 p.m. 1. Mr. Charles A. Carus-Wilson, "The Distribution of Flow in a Strained Elastic Solid." 2. Mr. C. V. Boys, (i) "Photographs of rapidly-moving objects;" (ii) "The Oscillating Electric Spark."

SATURDAY, MAY 3...Royal Institution, Albemarle-street, W., 3 p.m. Capt. W. de W. Abney, "Colour and its Chemical Action." (Lecture III.)

Foremen Engineers and Draughtsmen, Cannon-street Hotel, E.C., 7½ p.m. Mr. H. T. Crewe, "Recent Improvement in Gas Engines."

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FRIDAY, MAY 2, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

The Society's *conversazione* is fixed to take place at the Natural History Museum, Cromwell-road, South Kensington (by permission of the Trustees of the British Museum), on Friday, 27th June.

Each member will receive a card for himself, which will not be transferable, and a card for a lady. In addition to this, a limited number of tickets will be sold to members of the Society, or to persons introduced by a member.

Further particulars as to the arrangements will be announced in future numbers of the *Journal*.

CANTOR LECTURES.

The first lecture of the course on "Sugar, Tea, Coffee, and Cocoa, their Origin, Preparation, and Uses," was delivered by Mr. Richard Bannister, F.C.S., F.I.C., on Monday evening, 28th inst., the special subject of the lecture being Sugar.

The lectures will be printed in the *Journal* during the summer recess.

Proceedings of the Society.

FOREIGN & COLONIAL SECTION.

Tuesday, April 22, 1890: Sir Archibald Alison, Bart., G.C.B., in the chair.

The paper read was—

THE DANUBE AND ITS TRADE.

By Lieut.-Gen. Sir John Stokes, K.C.B.

In complying with the request that I should read a paper on the Danube, dealing with the question from its engineering and commercial points of view, I have felt some difficulty in deciding whether to make the paper an historical record of the two subjects combined or to treat them separately, and, if treated separately, which to put first.

I have come to the conclusion that it will be best to give you first an historical sketch of the condition of the river, and of its ownership as affecting its value to commerce; a condition which led to political interference in the interests of the corn-importing countries of the West. I shall then attempt to describe the works which have been carried out, the financial difficulties which impeded them and the arrangements for overcoming the latter, concluding with the effect on commerce produced by them, and with statistics showing the growth of trade.

The Danube, for the purposes of this paper, may be roughly divided into two very unequal parts—the part navigable at all seasons by sea-going ships, and the part navigable at all seasons only by river craft. The town of Ibraila in Wallachia may be taken as the point of division between the two, for although during floods sea-going vessels can navigate above Ibraila, during low water real sea-going ships cannot with safety do so.

The Danube rises in the Black Forest, and for 1,645 miles* to Ibraila traverses the German and Austrian Empire, the kingdoms of Hungary, Servia, and Roumania, separating the latter for 284 miles from the principality of Bulgaria.

Between Ibraila and the head of the Delta it receives two tributaries—the Sereth at Galatz and the Pruth at Reni—and rolls in its full strength from the latter small town for 30 miles to the Ismail Chatal (or fork), where it breaks up into the several branches of the Delta.

The Kilia branch from this point flows to the north-east past the towns of Ismail and Kilia, and 17 miles below the latter breaks up into another Delta discharging by seven channels into the Black Sea.

The Toultcha branch flows south-east from the Ismail Chatal, and 7 miles below the town of Toultcha separates into two branches, the

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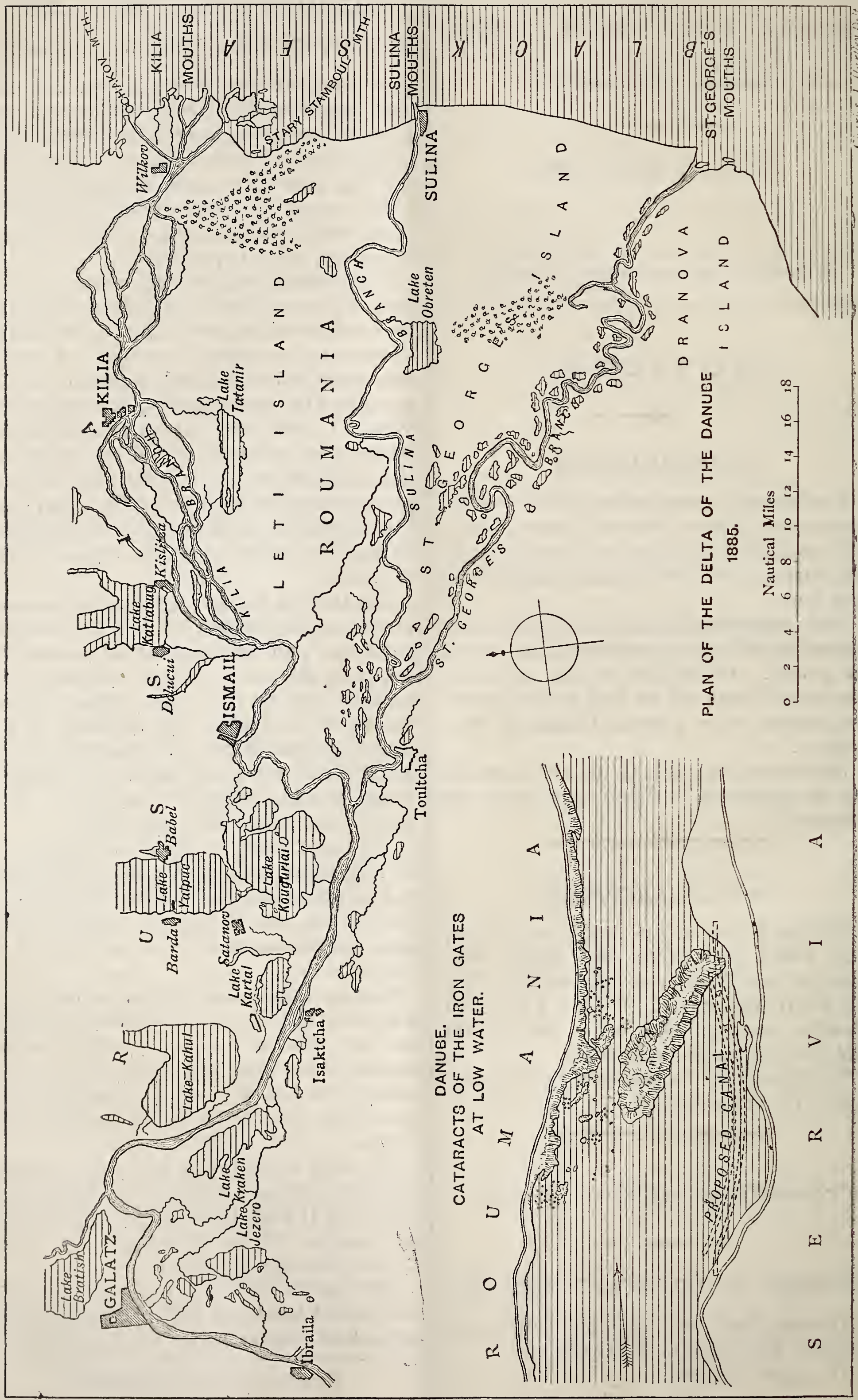
* The miles herein given are statute miles.



PLAN OF THE DELTA OF THE DANUBE
1885.

DANUBE.
CATARACTS OF THE IRON GATES
AT LOW WATER.

St. George's holding a general, though very winding, course to the south-east, discharging by two channels into the sea, and the Sulina branch taking a general east direction through many windings into the Black Sea, 20 miles south of the Otchakov mouth of the Kilia, and 20 miles north of the Kedrilles mouth of the St. George.

The point at which the Sulina branches away from the St. George is called St. George's Chatal.

The Sulina, which is the smallest of the three principal branches, was that which 50 years ago alone was navigable, there being according to the seasons from 7 ft. to 11 ft. of depth over its bar against 6 ft., the greatest depth at the Otchakov and Kedrilles mouths.

Before the Crimean War the trade of the Lower Danube was much hampered by the quarantine regulations, which Russia enforced on the vessels navigating the river. Early in the century Russia established herself on the Danube by the capture of Ismail, an important fortress on the Kilia or northern branch of the river; the whole of Bessarabia then became part of Russia. After the war with Turkey in 1829, she kept the mouths of the river and established a cordon of quarantine stations, extending from Reni, at the junction of the Pruth with the Danube, down to the mouth of the Sulina. The restrictions thus imposed on shipping, combined with the physical obstacles at the mouth and in the channel of the Sulina branch, made the exportation of grain from the rich corn-growing Danubian provinces a matter of much difficulty. The depth of water on the Sulina Bar was rarely more than 11 feet, frequently not more than 9 feet, and sometimes only 7 feet, whilst the navigable channels over the bars of the two principal arms of the river—the Kilia to the north and the St. George to the south—did not, as above stated, exceed 6 feet.

For some years after Russia took possession of the Delta, there were frequent complaints, made principally by Austria, of the state of the entrance to the river, and Russia was urged to dredge the channel. After the adoption of free trade by Great Britain, the demand for a free outlet for the corn of Roumania began to assume a louder tone. The exports, which had been only 313,591 Imperial quarters of grain in 1837 rose to 1,191,649 in 1846, and 1,826,647 in 1847. It began to be commonly asserted that Russia not only did nothing to remove the shoals, which obstructed the Sulina mouth, but that she sank vessels to make them worse than they naturally were, in order to prevent the Odessa trade from being injured by the growing importance of that from the Danube.

The recriminations between the Governments interested grew more and more bitter, until the outbreak of hostilities between Russia and Turkey in 1853, which culminated in the Crimean War.

Considering the great importance to Western Europe of the corn supply of the countries bordering on the Danube, and the complaints of many years as to the difficulty of getting it away, owing to the supineness of the Russian authorities in the matter of improving the channel, and their activity in hampering trade by quarantine restrictions, it is not surprising that all the negotiations for peace set on foot during the war contained provisions for placing the Danube mouths under European control, with a view to establishing free navigation in the river.

When at last peace was brought about by the Treaty of Paris, that instrument contained five clauses providing for the free navigation of the Danube. Of these, one concerned the regulation and improvement of the navigation of the main course of the river, where it traversed numerous States, and created a Riverain Commission to deal with these objects — another clause created a European Commission, whose duty was to "clear the mouths of the river, as well as the neighbouring parts of the sea, from the sands and other impediments which obstruct them." The other three clauses were common to the two Commissions.

The small town of Isaktcha, 14 miles above the upper point of the Delta, was named as the superior limit of the jurisdiction assigned to the European Commission of the Danube.

The Riverain Commission was formed on the lines of the Riverain Commission of the Rhine—created by the Treaty of Vienna of 1815—which treaty laid down the principles, on which rivers traversing several States were to be treated.

The European Commission was also intended to carry out those principles, but it was armed with powers which have made it an efficient executive and administrative body, and enabled it to carry out itself great works of improvement. The works ordered by the Riverain Commission had to be executed by the respective Governments in whose territories they lay.

The secret of the success of the European

Commission lay in the clause which provided that all tariff questions were to be decided by a majority of votes. In diplomatic conferences the decisions arrived at have to be framed in terms which all the contracting parties can agree to, and a great part of the work of the European Commission of the Danube had to be of that character, entailing often years of negotiation before an agreement could be arrived at; whereas all tariff questions, which were understood to comprise all questions affecting the outlay of money and the construction of works, were dependent on a majority vote, which ensured promptitude of action.

The Riverain Commission, according to the treaty, was to be permanent. The European Commission was expected to complete its task in two years, when its functions would pass to the permanent Riverain Commission.

This conception of the duration of the European Commission was probably due to the information furnished to her Majesty's Government by the British vice-consul at Galatz, a very able man, but not an engineer, and not competent to form an opinion on such a subject. His idea was that by a system of dredging on the bar, and by towing a heavy rake or harrow over it, the mud would be stirred up and carried away. The Russians, in their time, had, after much pressure, stationed a dredger at Sulina, and under the old Turkish *régime* a harrow had, it was alleged, been towed over the bar with good effect. The complaint against the Russians had been that they did not continue the old Turkish system, or attempt systematically or efficiently to use the dredger. The first efforts of the European Commission of the Danube were therefore naturally turned in this direction. They were directed to finish their work in two years, if possible; they knew that works would require a much longer time for their execution, and that a patient study of the problem was required to determine what those works should be, but they thought fit to show first what the proposed system was worth.

The dredger, therefore, was set to work, and a steam tug was made to tow the heavy harrow over the bar. After several weeks' work a few inches of depth were gained, but the very first gale of wind filled up the bar again. It was evident that no useful effect was to be obtained by either dredging or raking.

The European Commission had not expected any result from these systems, though they had been bound to try them; and I must be allowed to express my conviction here that the Russian Government had been unjustly maligned, and that nothing could have been done by their agents on the river in this direction; also that the accusation made against them of having encouraged the silting up of the entrance by sinking vessels was equally unjust and unfounded. The method of carrying on the trade, and the character of the climate, fully account for the number of wrecks at the Sulina mouth previous to the successful improvement of its channel by the Commission's works. There is small blame to be attributed to the Russians for not having undertaken such works themselves. There was so great a division of opinion and uncertainty amongst engineers as to the best mode of improving the river, that several different methods were suggested, some of which were bound to fail, and it is due to the careful study and patient investigation of all the data that could help to solve the problem, and to the skilful tentative works of the eminent engineer whom the Commission employed, that a new engineering triumph has been achieved. How doubtful engineers were at that time as to the manner in which a tideless river should be treated, is evidenced by the fact that her Majesty's Government were informed by their technical advisers in London that the European Commission were merely throwing money into the sea, and telegraphed twice to their Commissioner to discontinue the works which have since achieved such success. The Commissioner, happily, felt himself unable to follow the instruction thus given, as he had voted with his colleagues, and was bound to go on.

The European Commission first met in October, 1856, and found itself in this position: it was dependent on Turkey for funds to carry on the duties entrusted to it, as that Power had engaged to make the required advances, and refused to allow other Powers to do so. It had no data on which to form an opinion on the best method of overcoming the difficulties which rendered the navigation of the river dangerous. It found the trade paralysed by disorders of every kind; the only vessels which could enter the river were brigs and schooners of 150 to 300 tons, and even these could only pass over the numerous shoals in the river, and over the bar at the mouth, after being lightened.

These vessels, when in ballast, made their way slowly up the tortuous river, at times helped by a fair wind in some reaches, but hauled up against wind and stream by their crews toiling on the river banks when the wind was foul, as it was bound to be in some of the windings. It thus took them weeks to reach the ports of Galatz and Ibraila, where they received their cargoes of grain. A few secured the service of a steam tug to avoid this long delay and heavy labour, but there were few tugs on the river, and their charges for towing were exceedingly high.

The difficulties of the descending laden vessels were almost greater than those of the vessels in ballast toiling up the stream; for although during the spring they had usually a fair depth in the river, owing to the floods, in the autumn, after harvest, the water was generally low, and as soon as vessels entered the Sulina branch, they were frequently stranded on the shoals, which obstructed the navigable channel. There they had to remain until lightened of a part of their cargo. The ports of Sulina, Toultcha, Galatz, and Ibraila swarmed with small vessels used for the purpose, and owned and worked by a set of Greek sailors, who were little better than pirates. As soon as a vessel got ashore she was obliged to employ these fellows to lighten her, and they robbed her of the grain entrusted to them by all kinds of devices—by false bottoms, by boats carrying off part of the discharged grain during the night, &c. The pilots were generally in collusion with the lightermen, and provided for their employment by running vessels aground, when careful steering would have taken them through without grounding. It was, however, at the mouth of the river that the greatest evils of lightening occurred. Arrived at Sulina, a vessel had to lighten until she drew only eight feet of water at most times. She had then to await a perfectly fine day to go out on to the roadstead with the lighters containing her cargo. Often while taking the grain on board a gale would spring up or the wind freshen, so that the lighters could no longer remain alongside, and they would run into port; often they were wrecked, and sometimes the vessels lying at anchor in the roads were driven ashore or got their cargo shifted, and, if nothing worse happened to the vessel in the roads, she was pretty sure not to get back all the grain that had been put into her lighters.

The Commission had thus, it will be seen from the foregoing, no easy task before it.

For the engineering works, surveys of a detailed nature had to be made, and observations taken to determine the action of the river, and the best mode of controlling it. For the administration and regulation of the navigation, a lawless population, accustomed to the licence of war, which had been prevailing for three years, and which, previous to the war, had had no acquaintance with settled law and honest administration, had to be brought under control and made to respect authority, and deal honestly with traders who came from the West to seek grain.

The Commission set itself to achieve these objects by summoning a competent engineer and surveyors from England, and by forming a staff of officials to frame and administer laws, and control the population in order to protect trade.

The engineer, Mr. (now Sir Charles) Hartley, had no easy task, for there was absolutely no information available as to the resources of the country, nor any data on which he could base his calculations. Whilst accurate soundings and surveys over a vast area had to be obtained, and accurate measurements made of the volume and velocity of the river in its several branches, and of the matters held in suspension under the varying conditions of the river at different times of the year—in spring and summer, when swollen by the mountain floods—in the autumn and winter, when the water was low or frozen—the engineer was pressed to hurry his report and make some recommendations of works to be carried out. The problem was a complicated one, for it was uncertain what was the best system of work to be adopted, or which was the arm of the Delta that ought to be treated.

A measurement of the volume of the river and its branches showed that 17-27ths of the main Danube at Isaktcha passed down the Kilia branch, 10-27ths down the Toultcha Branch, which again sent 2-27ths only down the Sulina and 8-27ths down the St. George. Yet as above stated the Sulina, though discharging only 2-27ths of the whole river, had the deepest navigable channel at its mouth.

The measurement of the matter held in suspension showed that in the Sulina during ordinary flood 602 cubic feet of solid matter was carried seaward per minute, whilst after the floods had subsided only 17 cubic feet per minute were so carried. By the same proportions it will be seen that the main stream, the Kilia, carried in time of ordinary flood over 5,000 cubic feet of solid matter per minute to the sea, and after the floods had subsided this was reduced to 145. In the St. George's branch these figures would be 3,010 and 85.

The Kilia branch undoubtedly possessed some features which made it more attractive. Its channel for 44 miles is the straightest and deepest of the three branches from the head of the Delta to the sea, though frequently separating into several branches and converging again; but at 7 miles from the sea it separates into seven channels forming a sub-delta, and the shoals over which these branches discharge into the sea showed such a rapid advance that their treatment did not offer any hope of success. Moreover, the difference of distance from the head of the Delta to the sea some 2 miles shorter as compared with the Sulina and 14 as compared with the St. George's, is more than counter-balanced by the increased distance from the Bosphorus, through which the bulk of the trade passes. The Otchakov mouth of the Kilia, that which offered the best conditions for treatment, being 20 miles further from the Bosphorus than the Sulina mouth, 40 miles further than the Kedrilles mouth of the St. George, and during the prevailing winds this entrance is to windward of those mouths—a matter of much importance to the sailing vessels, which, in 1857, formed the great bulk of the Danube navigation.

The rejection of the Kilia branch from consideration, for the above valid reasons, left the choice to be made lying between the Sulina and the St. George. The latter branch possessed many advantages which weighed in favour of its adoption. Its course, though winding, was so broad and deep as to make the navigation easy, and the bends themselves were so acute as to make works for straightening the river by cuttings most desirable as shortening the river very considerably. The river bed from the St. George's Chatal to Kedrilles was obstructed by very few shoals, and the Kedrilles mouth through which the bulk of the St. George's branch discharged into the sea, took an easterly direction at right angles to the littoral current of this shore of the Black Sea, a condition which the works at the Sulina mouth have since shown to be susceptible of successful treatment.

On the other hand the the Sulina branch was as well as tortuous, encumbered by frequent shoals, and so narrow that the navigation of its numerous bends was difficult and led to vessels frequently grounding on the banks, or being much delayed by the difficulty of warping round them. The points in favour of Sulina were the existence at the mouth of the best navigable channel in the natural condition of the river, and of the mass of solid matter annually discharged into the sea being so much less than that carried down by the St. George, its direction in relation to the littoral current being the same.

At the Sulina mouth and in its branch there was, however, the disadvantage of having to work whilst the waterway was encumbered with traffic; whereas in the St. George there would be no passing vessels to interfere with the dredgers, stone barges, &c., engaged on the works.

The estimated cost of the works proposed was as follows:—

The St. George.

Works at the Kedrilles mouth for deepening the entrance	£663,921
Works in the branch	198,361
Total	£862,282

The Sulina.

Works at the mouth to remove the bar	£307,216
Works in the branch for cutting off bends and removing shoals	245,930
Total	£553,146

Mr. Hartley's projects for these works were laid before the European Commission in October, 1857, together with a report treating the whole question. This gave rise to an animated discussion, in which a very marked difference of opinion manifested itself. The Commissioners of Great Britain, Austria, Sardinia, and Turkey declared themselves in favour of the St. George; those of France, Prussia, and Russia for the Sulina; the Russian Commissioner, however, stating his preference for the opening of the Kilia branch, could it be effected.

The result of this want of unanimity led to the assembling in Paris during the spring of 1858 of what was called the Technical Commission of the Danube, to which, however, only four of the Powers represented at Galatz sent delegates, namely—France, Great Britain, Prussia, and Sardinia.

This body endorsed the choice of the St. George, but recommended an entirely different system of works. Mr. Hartley had proposed to deepen the channel over the bar in each instance by means of parallel piers led out into deep water across the bar, thus concentrating the river current within normal limits and sweeping away the sand and mud barring the entrance. The Paris Technical Commission had no faith in this system. They maintained that it would have no lasting effect, and they proposed in place of it a lateral canal, which should pass from the St. George's branch, at the head of the Kedrilles Pass, into the sea to the north of the bar. This canal was to be closed at the point of its departure from the river by locks to keep out the river mud, and in its course was to pass through a spacious basin in which were to lie vessels waiting to enter the river or to put to sea. The depth of water on the sill of the lock gates was to be 16 feet.

The Paris Commission urged in support of its views the success which had attended similar works at the mouth of the Vistula, and the failure of parallel piers at the mouth of the Rhone—whilst they adduced the Ebro and Elbe as further instances in support of the lateral canal system; but these rivers discharged their waters into their respective seas under conditions entirely dissimilar to those prevailing at the mouths of the Danube. The description of these dissimilar conditions is very interesting, but the limits of this paper do not allow of their being here given.*

In the meantime, during the delay which was thus engendered, the Commission considered that an endeavour should be made to improve the Sulina mouth by provisional works, in order to benefit the navigation as far as possible pending a decision as to the best mode of permanently opening the Danube—and the execution of such works as might be adopted. To this end instructions were given to their engineer in March, 1858, to submit a project for the Sulina provisional works, the cost of which should not exceed £38,000. This was submitted by Mr. Hartley in the following April, and provided for two phases of works, the first estimated at £38,424, which would restrict the length of the north pier to 2,940 feet, and of the south pier to 1,730 feet; the second at £74,037, which carried out the north pier to a length of 4,380 feet, and the south pier to 3,000 feet; but Mr. Hartley warned the Commission that he did not expect the first phase to produce the desired effect, namely, a deepening of the channel by two feet for a period of five or six years. The first phase was however approved, and he was instructed to begin work forthwith.

Having during the summer of 1857 proved that neither dredging nor raking on the bar was of any durable effect, Mr. Hartley proposed to make the river current itself do the work without the aid of dredging. In its natural conditions the river as soon as it ceased to be confined between two banks spread out like a fan, and at once losing its velocity threw down the solid matter which it carried in suspension, and thus formed the bar which obstructed the entrance. The engineer's plan, as provided for in the second phase, was to continue the restraining action of the river banks by means of parallel piers across the bar, until the current should reach the prevailing littoral current. The two currents mingling would take the direction of the resultant of their forces, and thus the deposit of solid matters would take place, not across the entrance but towards the south-east of it. Mr. Hartley proposed to effect this rapidly and cheaply, but by works of sufficient strength to resist the attack of the heaviest seas, by means of timber and *pierres perdues*, blocks of stone thrown in *pêle-mêle*. He hoped to avoid heavy piling from floating platforms in an exposed seaway by the use of cribs filled with stone, and protected by stones thrown in round the base; the intervals of from 20 to 30 feet between the cribs being filled in by piles protected by the *pierres perdues*. These cribs were constructed like the cribs employed in the United States and Canadian sea and river ports, and were composed of horizontal logs tied together by strong treenails, strengthened by iron rods. Three of these cribs were successfully launched, filled with stones, and sunk on the alignment of the north pier, and their foundations protected by *pierres perdues*. One was carried away in the first severe gale after their being put down, but two remained firm. One formed the head of the pier for six winter months, 1858-9, and resisted all the attacks of the sea. Mr: Hartley, however, decided, from motives of economy, to abandon the use of them, except as provisional pier-heads during the winter months, and to continue the main work with only piles and stone. The piles were carried out in three rows, tied together transversely and longitudinally by heavy crossbeams, and walings bolted through the heads of the piles; the outer row alone was filled up with close sheeting, the foot of which was protected with

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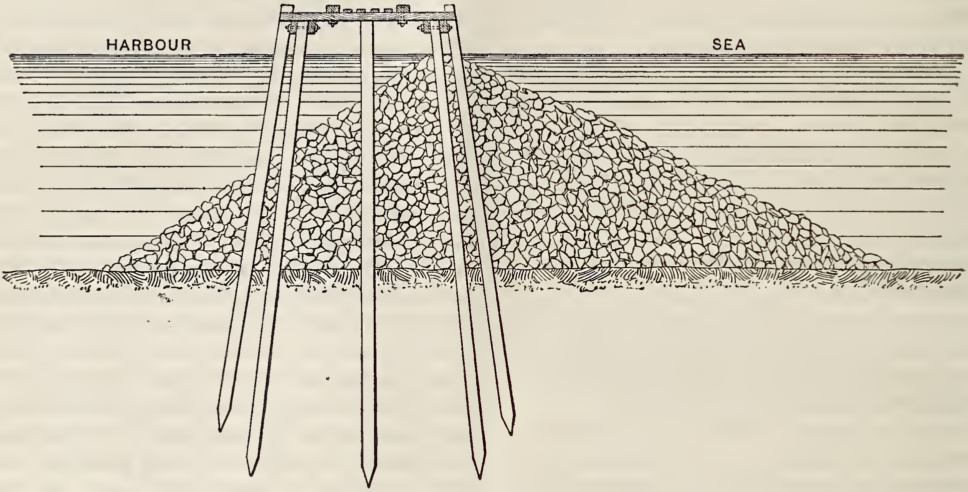
* Full particulars of these rivers and their works are to be found in vol. xiii., new series of the Professional Papers of the Royal Engineers for 1864, given by the Author of this paper.

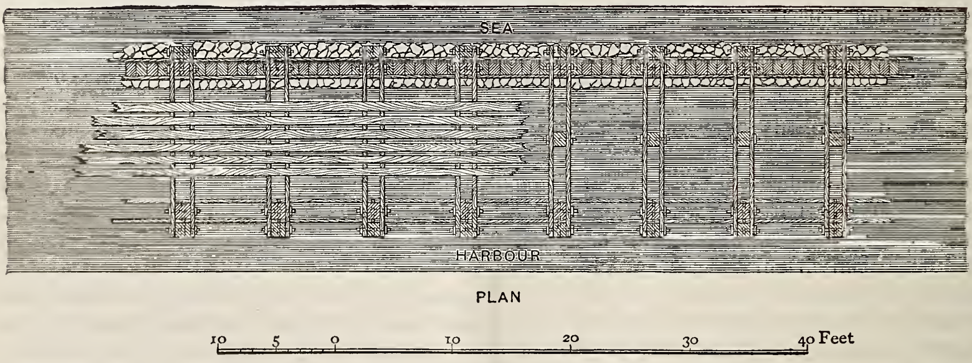
pierres perdues thrown in on both sides, and taking their natural slope from a foot above the water-line to the bottom. This system was found to answer very well, and the work went on as expeditiously as the weather would permit. Storms would occasionally carry away the head of the work before the full amount of protecting stone could be got down, but damage of this kind was quickly made good.

In order to insure the necessary supply of materials, not only the delta and neighbouring territories, such as the forests of the Dobrudscha, were carefully examined for timber and stone quarries, but the Carpathian Mountains, the district of the Save, and Odessa were visited by the engineers and some of the Commissioners.

Fig. 2.



TRANSVERSE SECTION



PLAN

Piers at the Sulina Mouth (Provisional Works).

From the Dobrudscha forest only hornbeam trees supplied piles of the length required. The oak, though of excellent quality, was short and crooked, well adapted for shipbuilding, but not for piles. The Carpathians furnished magnificent masts, and many of the Commission wants were supplied from this source, but the timber was a soft porous pine, not well fitted for piles. From Odessa, a harder pine, in beams of dimensions well suited to this work, was obtained, but the piles did not long resist the action of the water, and had to be replaced. It was from the banks of the Save, above Belgrade, that the best timber for the work, beams of marsh oak 40 feet long, and of 12-inch scantling, were got. This oak was not so hard as the local oak, but it was straight and admirably adapted to the purpose. This supply was not discovered at first, but it came in opportunely for the outer ends of the piers which, being in deeper water, had to resist the greatest strain. This timber was the most costly, as it had to be brought down in barges 600 miles, whereas the Carpathian timber was floated down in rafts. The Dobrudscha logs were taken only 50 miles in the Commission's own barges, and the Odessa timber had but a short sea voyage to make.

The stone used was quarried principally in the Grauwacke, which abounds at Toultcha, and was conveyed to Sulina in the Commission's own barges, several of which were built for this purpose, though at first lighters only were employed.

The works generally were carried out by the Commission's own people; stone and timber were obtained by contract, but a careful consideration of the circumstances of the country led the Commissioners to the conclusion that it would be more economical to carry on the work by their own engineers and foremen than by contractors. There were no local firms having knowledge or experience of works, and such contractors as were to be found based all their calculations on making enormous profits and fraudulent deliveries. It was, therefore, better to form an efficient body of workmen and superintendents, and reap the benefits of honest work, with a certainty of time and materials not being wasted, than to pay an exorbitant price to contractors to gain their experience. The result has been that the works have been accomplished for a very small sum of money, and with great rapidity.

The difficulties at the commencement of the works were very considerable, from the absence of skilled workmen. The Commission obtained one or two assistant engineers from Prussia, as well as from England, for river works; but at Sulina the mechanics and foremen were English. Some Greeks proved to be good gangers; and some Greeks and Turks became excellent workmen, the latter especially proving very reliable, as well as being powerful fellows in handling heavy weights, and contending with the rough seas.

By the end of 1858, the north pier had advanced 1,740 feet, its full length, as then approved, being 1,960 feet. The south pier had advanced 250 feet of its total length of 1,030 feet. During the winter months, from November to March, nothing could be done in the way of sea works. In September, 1859, the works had advanced with such rapidity, that the Commission decided to carry out the whole project, and to extend it. By the end of the year, the north pier was carried to 2,850 feet, of which, for 2,650 feet, the foot of the piles was protected by rockwork; and the south pier was extended for 1,358 feet, of which 340 feet were protected by stone. In April, 1860, the Commission received the report that the floods, guided by the north pier alone, had deepened the channel over the bar to 14 feet; and those who had maintained that a single pier would be sufficient for the improvement of the river, began to claim credit for the justice of their predictions; but after a few weeks, as the floods subsided, this channel quickly filled up again, the depth across the bar falling off to only 8¼ feet, and the necessity for the second pier was no longer doubted. This was now pushed on with great rapidity, for, being under the lee of the north pier, work could be carried on upon it during weather which stopped all work on the north. By the end of 1860, the south pier had reached its projected length of 3,000 feet, and the north pier had been carried out to 4,640 feet, or 260 feet beyond its proposed length, in order to insure a better shelter for vessels at the entrance during the prevailing N.E. winds, and their effect during the following spring was anxiously looked for. It fully justified and more than realised the hopes of the engineer, for in March the depth was 14 feet, and it went on steadily increasing till it had reached 17½ feet in July.

This great success was marked by a formal inauguration of the works in 1861, at which all the Powers and the great commercial interests were represented. The Sultan marked his appreciation of the event, and of the skill of the engineer, by conferring on Mr. Hartley the Fourth Class of the Order of the Medjidie; and in the following year her Majesty bestowed upon him the honour of knighthood.

As the provisional works were approaching completion the French and Russian Commissioners made a determined effort to bring about the dissolution of the Commission on the ground that it had completed its task, and that any works remaining to be done might very well be carried out by the Riverain Commission under Art. 18 of the Treaty of Paris. The moment was well chosen, as the Austrian Commissioner was absent on leave, and the remaining Commissioners, except the British, were either indifferent or secretly desired to see the Commission's labours brought to a close. The British Commissioner had therefore to fight the battle single-handed. He maintained that the task of the Commission could not be considered as completed until the Sulina branch had been placed in a position of navigability corresponding with the results obtained at the mouth. He succeeded in staving off any decision, and on the return of the Austrian Commissioner the Commission decided to secure the results of its administrative measures by drawing up a Public Act, to be ratified by all the Powers; and to carry on the works in the Sulina branch. The negotiations for the ratification of the Public Act lasted four years, during which time the Sulina piers were maintained and strengthened. They had done their work well, and the results obtained had exceeded all expectations—a broad 17 feet channel had been opened to navigation where only 12 feet had been expected; but the piers were temporary in their character; the piles, where exposed to the alternate action of air and water, decayed; the loose *pierres perdues* were beaten down by the action of the waves; and it was evident that works of a more permanent nature were required to perpetuate the improvement already effected, and which it was hoped that such permanent works would increase. For although the provisional piers did so far confine the river current as to sweep away the bar and maintain a channel of 17 feet, it could be seen that a considerable portion of the river water escaped through the piling and loose stones, and that thus much of the scouring force was lost, to the detriment of the channel.

When therefore the Public Act was ratified in 1865 it was finally decided to give up the idea of opening the St. George and to concentrate the resources of the Commission on the consolidation of the provisional piers and the improvement of the Sulina branch, according to a well-digested scheme submitted by Sir Charles Hartley. The Commission approved in the autumn of 1865 the plans and estimates submitted by their engineer for the conversion of the Sulina provisional works into permanent works, and for the improvement of the Sulina branch.

But for some time the financial difficulties of the Commission, which will be explained presently, did not allow of very active prosecution of the works. It was only in 1868, the required funds having been obtained, that the engineer could set to work seriously to carry his project into execution. The system of works recommended by Sir Charles Hartley, and adopted by the Commission, was to solidify the loose stone work of the piers, and to build on the foundation thus obtained a solid wall of *béton* blocks.

After trying experiments with concrete of various proportions of cement the engineer decided on those best adapted to combine the required strength with the greatest economy, and succeeded in converting the north pier into a solid rib of artificial rock. This rib was 5,332 feet long, 10 feet thick, and of varying depth from 5 feet below the water line for 4,732 feet, and from 6 to 14 feet below the water line for the 600 feet of pier head. This last 600 feet was, moreover, protected by blocks of *béton* of from 10 to 20 tons in weight lowered from pontoons on the outer slope of the rockwork adjacent to the head of the pier. The increase of length is due, not to extension seawards, but from the degradation of the coast line, which made it necessary to extend the north pier inwards.

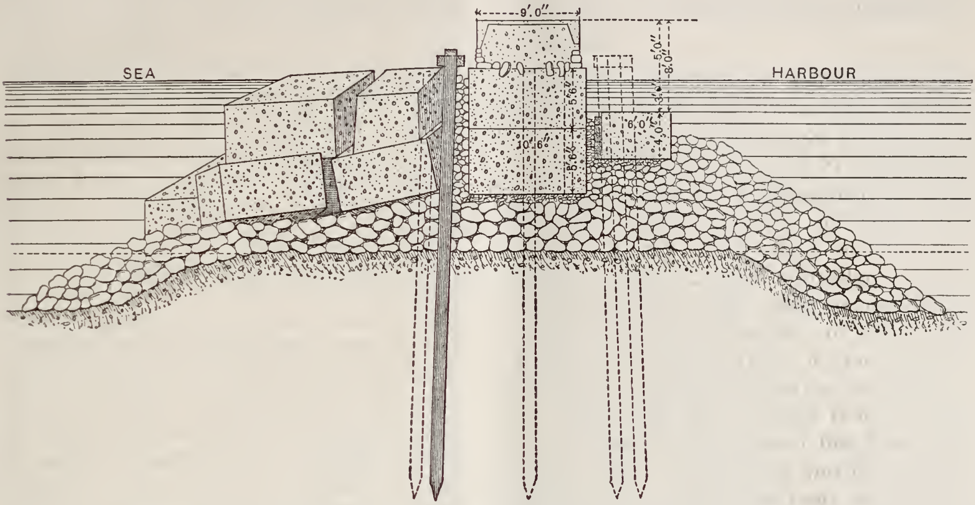
The nature of this work can be seen on the sections attached. It will be seen that the beat of the sea upon the *pierres perdues* of small size, which formed the provisional pier, spread them out at a gentle incline, well compacted and driven together so as to form a solid foundation for these heavy blocks.

The south pier was consolidated in a similar manner, but did not require blocks of the same solidity and section as the more exposed north pier, or the protection of heavy blocks thrown in round the pier head.

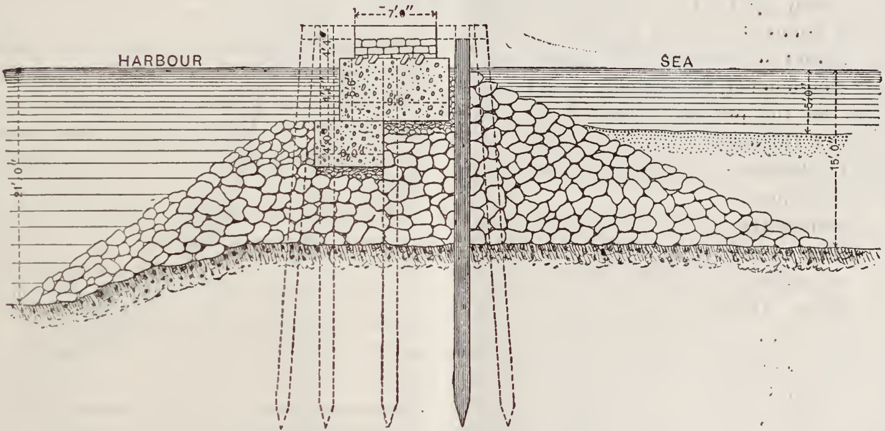
The technical details of the works would make this paper too long; they are to be found in vol. xxxvi. of the "Minutes of Proceedings of the Institution of Civil Engineers," where Sir Charles Hartley himself gives a minute description of them in his very able paper upon this subject.

During the progress of these works, it was decided to prolong the south pier for 450 feet, in order to give a greater length of parallelism to the piers, and thus reduce the space in which a shoal could form under shelter of the north pier. Such a shoal had, in certain states of current and wind, been thus formed from time to time, as above mentioned. This shoal had formed in the autumn of 1863, but was swept away in 1864. It formed again very suddenly in 1866, but was quickly dispersed without artificial aid. In 1869 it again formed, and it was then decided to prolong the south pier to the extent above named—450 feet—which was carried out in the same year. In 1876-77 another prolongation was made stil further to fix the channel, and to bring the pier head to a point immediately opposite the north pier head. Since that time the entrance has never been seriously obstructed.

Fig. 3.



NORTH PIER. CROSS SECTION FOR A LENGTH OF 100 FEET NEAR PIER HEAD.



SOUTH PIER. CROSS SECTION NEAR PIER HEAD.

10 5 0 10 20 30 Feet

Piers at the Sulina Mouth (Permanent Works).

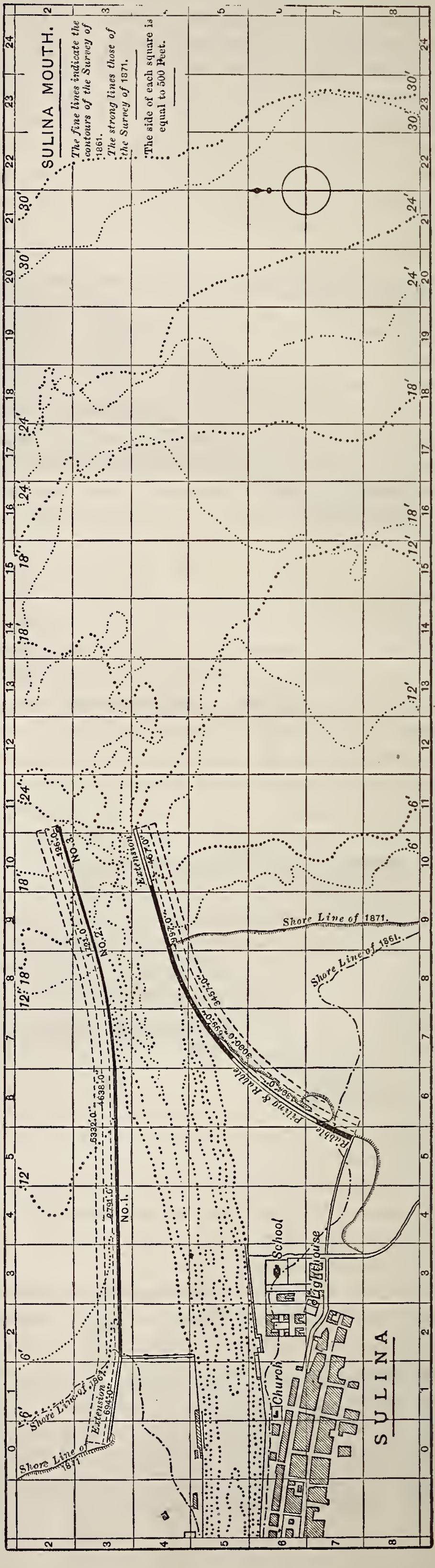
The consolidation of the piers, begun in earnest in 1868, was completed in 1871. The immediate effect was to increase the depth to 22 feet in 1871; but as there was a shoal within the piers on which there was only 19 feet of water, only that depth was available for vessels navigating the river. In 1872, this inner shoal was also removed, and for the last eighteen years an available depth of 20½ feet has been constantly maintained at the Sulina mouth. This striking improvement over the 7 feet to 11 feet previous to the works has been effected for the modest sum of £238,980, including maintenance for 25 years (1861-1886):—

The provisional works cost	£86,541
Their consolidation, completed in 1871	44,884
Prolongation of south pier in 1869	8,198
The maintenance of the works, 1861-1871	45,778
Consolidation and prolongations, 1871-1886	11,920
Maintenance for 18 years of works, work-shops and floating plant	41,709
	£238,980

The works which have just been described are almost identical with Sir Charles Hartley's first projects in 1857, which were emphatically condemned in 1858 by an International Commission of distinguished engineers—who had never visited the ground—in the following terms:—"The Commission cannot recommend the application of the proposed system of improvement, which offers no guarantee of success. As for the projects for the Sulina mouth and branch, they ought not to be carried out: their success is very uncertain; they will cause the total loss of very large sums of money, and will even throw obstacles in the way of the existing navigation." And even in stronger terms than these they condemned his plan of provisional piers at Sulina, which in three years' time (1858-1861) increased the depth on the bar from 8½ feet to 17 feet, at an expense of only £86,541. These provisional works, they reported in 1858 to their Governments, "should be immediately abandoned, if already commenced, for not only would they be useless for the purpose intended, but the guiding-piers themselves would speedily be destroyed by the force of the waves, owing to their feeble section."*

As a commentary on the above, attention may be drawn to two facts, namely, that the works so unsparingly criticised in 1858 have resisted without damage the attacks of the heaviest storms up to this time, and that experience has abundantly proved that the predictions of a rapid silting up to seaward of the Sulina piers, which were so prevalent at one time, were happily unfounded; for, on the

FIG. 4.



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* As a substitute for the parallel pier system at the mouth itself, the Technical International Commission recommended, as stated in this paper, the construction of a lateral canal 16 feet deep to the St. George's branch of the Danube from a point on the sea-board about ½ mile to the north of St. George's mouth, at an estimated cost of £360,000. If this plan had been executed, the cost of the canal up to this time, including maintenance, would have amounted to at least £600,000, and the navigation, instead of enjoying as at present a depth of 20½ feet at a wide, open mouth, would have been compelled to enter and leave the Danube through a narrow locked entrance of solid masonry with only 16 feet of water over its sill.

contrary, the entrance was never so free from sandbanks as at this moment, as will be seen at a glance on referring to the last survey of the Sulina mouth in December, 1889.

Having shown you the continuous development of the works at the mouth of the Sulina, I will now endeavour to trace the steps which have been taken during the last 34 years to render the Sulina branch less difficult for the passage of vessels.

One of the first matters which engaged the attention of the Commission when it met in 1856 was the obstruction existing at a shoal about 49 miles from Sulina, and 4 miles from the St. George's Chatal. At this point a small stream called the Papadia left the Sulina to join the Kilia branch. This stream, combined with an abnormal width at this section of the river, caused a check to the current, and consequent deposit of solid matter over a large area called the Argagni.

The closing of the Papadia, and the employment of dredges on the shoal was the first engineering work undertaken by the Commission, and I mention it to show the small beginnings from which the great work, since accomplished, started. It produced a temporary effect, which, however, was soon lost, for dredging is but of little avail, unless accompanied by works which remove the cause of the shoal, and the Papadian diversion was only one of the causes of the Argagni shoal. The principal cause for the formation of a shoal is a check to the rapidity of the current, which at once precipitates to the bottom the heavier particles carried in the water. Such a check is generally due to one or other of the following causes, sometimes to all combined:—

1. The widening of the river beyond its normal width by the falling in of the banks.

2. The too sudden convolution of the bends which makes the degradations of the banks more rapid, and

3. By the meeting of currents due to such sudden convolutions causing back eddies.

The remedies for these causes adopted by Mr. Hartley were the following:—

1. To narrow the river to a width of from 350 to 500 feet by means of groynes or spurs thrown out from the banks, and by training walls to direct and maintain the current in the best direction.

2. By revetting with stone the concave bends, and thus preventing their being eaten away or degraded by the current.

3. By cutting off the most contorted bends of the river, which, while straightening the river and making navigation more easy, gave to its current a gentle uninterrupted flow, and thus prevented any serious back eddies.

Some idea of these works may be gathered from the maps on the walls, where the works at the Argagni are shown, on which a combination of the systems 1 and 2 are given.

An exemplification of the third system may be seen at the cutting off of the bend known as the M from the contorted course of the river at this point. This cutting was undertaken in May, 1868, and terminated in November, 1870, It not only guided the river so as to get a more uninterrupted flow, but shortened its course by a mile, and thus also to some slight extent accelerated the current, which at low water is very sluggish.

One of the most difficult problems to solve in the river was the removal of the shoal at the St. George's Chatal. It will be seen that the Sulina branch on leaving the main river folded back on itself, and by constantly eating into the point made the angle more and more acute. It was sought to remedy this by revetting the bank on which the current impinged, by gathering in and directing the stream by a curved projecting arm in continuation of the attacked bank, and by throwing out opposite to it an extensive and strong groyne, so as to fix the current on the channel in which it was necessary for it to run to enable ships to pass up and down. These works were continued for 15 years, but the shoal was constantly reappearing in one form or another, until Sir Charles Hartley at length, in 1880, took the bold course of recommending the Commission to cut an entirely new departure for the Sulina from the main stream, by which it should leave the latter at a gentle angle. There was a double advantage in this for the navigation, as not only would vessels have an easy channel to navigate at this point, but they would avoid the sudden windings of the old branch just below the Chatal. This cutting was most successfully carried out in two and a half years, from June 24th, 1880, to December 9th, 1882, and no difficulty has since been experienced at this point. The profile given to these and other cuttings is 300 feet at the bottom, and 370 feet from bank to bank.

In 1871 a growing danger to the navigation was observed, namely, the formation of a shoal across the Toultcha branch, just opposite to the Ismail Chatal. The full weight of the river bearing upon this point, it was interesting to observe

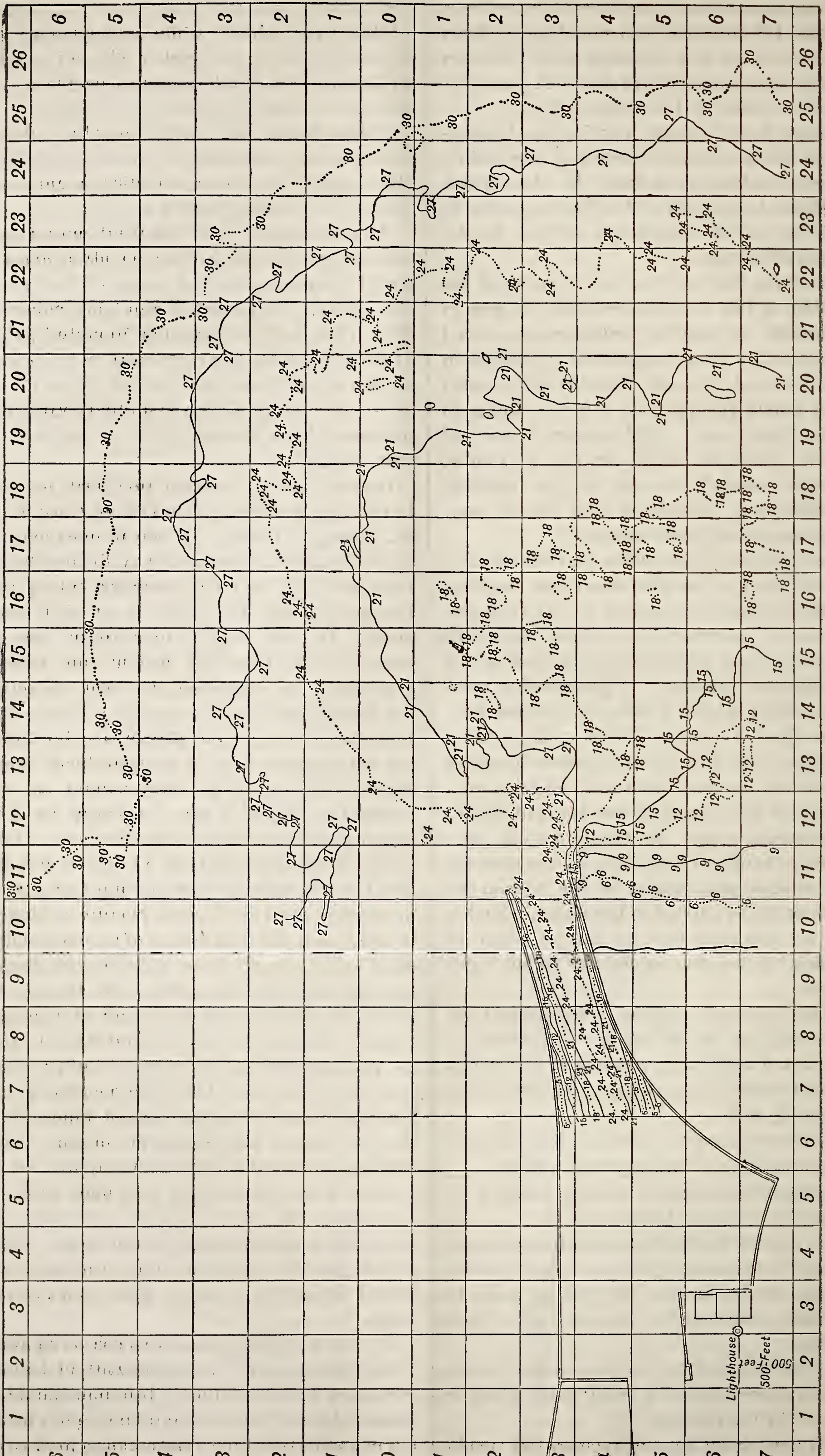

Fig 5.—Survey of the Sulina Mouth, December, 1889.

whether the same character of works that had succeeded so well in the small Sulina branch would attain the same result in the main river. Works of the kind were planned, and in three months, from September 1st to December 9th, 1873, carried out with entire success, as the attached plan will make clear.

From 1857 to the present time, 17 shoals in the Sulina branch have been removed by the continuous application of works on the above principles, and six cuttings have been made by which the distance from the St. George's Chatal to the sea has been reduced from 52 to 49 miles. The river may indeed be said to have been canalised by these works, so regular are its course and width at the present time.

The cost of these works to 31st December, 1886, was £386,200, including £48,152 expended in the purchase of dredging plant, much of which is still available for future works. The gradual improvement effected by this outlay is well shown by the following figures. The least depth in the Sulina branch at lowest water was—in 1856, 8 feet; 1865, 11 feet; 1871, 13 feet; 1886, 15 feet, and is now from 15 to 16 feet at low water, whilst at the season of high water there is a navigable channel of from 18 to 21 feet.

There is still a further improvement of the Sulina branch under consideration by the Commission. From a point eight and a half to another eighteen nautical miles from Sulina there is a very large bend comprising in its course three smaller curves, which impede the navigation of the long steamships which now frequent the river.

Sir Charles Hartley and the resident engineer, Mr. Kühl, have submitted alternative projects for the removal of these difficulties. The best and most complete remedy is to cut an entirely new channel avoiding the whole bend. This cutting would be 6 miles in length would cost £152,400, and require six years to cut.

The alternative is to straighten the smaller curves, which would cost £57,000, and to deepen the navigable channel where required by means of narrowing works between the 8½ and 18 mile posts.

The advantage of adopting this alternative is, that as each cutting and section of training works is completed, the navigation at once gets the benefit of it, and the total cost, £105,000, is less. On the other hand, the larger and more complete project effects a saving in distance of 4¼ miles, whereas the alternative gains only two-thirds of a mile. The larger shortening would have the effect of giving increased velocity to the current, which is desirable.

The remaining engineering works of the Commission were—

1. Surveys, on which alone a proper estimate of works could be formed.

2. The removal of obstacles from the river channel, whether at the mouth or in the course of the river.

3. The construction of quays at Sulina, buoying the best channel in the Sulina branch, and providing other facilities for trading operations.

4. The erection of necessary buildings, including lighthouses.

(1.) For the solution of such a difficult problem as the improvement of a river, careful surveys, extending over several years, are required, but the engineer who had to deal with this problem in the Danube, in 1857, had to guide him only a few naval surveys made at the time by Captain T. Spratt, C.B., R.N., and a Russian survey made in 1829, to which were attached no data for comparing the level to which the soundings were reduced with those taken 28 years later.

The problem, however, had to be solved at once, and the engineer determined to trust only to his own surveys and measurements, in which he was faithfully aided during nearly 20 years by Mr. Robert Hansford, a very careful and skilful surveyor engaged for the purpose. The three atlases which lie on the table, prepared under Sir Charles Hartley's directions, embracing the periods 1857 to 1865, 1866 to 1873, and 1874 to 1886, contain a record of the conditions of the coast line, of the river mouths, and of the river channels, which will guide any future engineer in treating the Danube, and which I believe to be as complete as can be shown for any river in the world. The memoirs which accompany these atlases give a mass of technical information as to materials used, the direction and force of winds and currents, the amount of matter carried down by the river, &c.

(2.) Numerous wrecks were removed at the mouth of the Sulina, and in its course to the sea, mostly by explosion of charges of gunpowder and dynamite.

(3.) Quays, alongside of which vessels could lie at Sulina, and bollards to which they could moor, both in the port of Sulina and at difficult parts of the river, for warping and other purposes, were fixed by the Commission, and a system of buoys was laid to mark all difficult channels from Ibraila to the Sea.

(4.) The Commission erected lighthouses at the mouth of the St. George, and at the extremities of the north and south piers at Sulina, which they still maintain. Buildings for public offices and for the use of their *employés*, as well as a hospital for seamen, have also been erected at Sulina.

Sir Charles Hartley acted as engineer in chief to the Commission from 1857 to 1872, residing at Sulina and personally superintending the works, which derived the greatest benefit from his careful attention, economical management, and highly skilful and practical manner of dealing with the difficulties which successively arose. Since 1872 he has been consulting engineer, visiting the Danube once or twice a year as required. All projects for works up to the present time have emanated from him, and during the last eighteen years they have been thoroughly well carried out under the personal superintendence of Mr. C. Kühl, a Danish engineer and M. Inst. C.E., the resident engineer since 1872.

This sketch of the engineering works of the Commission will not be complete without some account of the financial arrangements by which they were provided, and of the financial difficulties which from time to time almost paralyzed them.

When the Commission was formed, the Sublime Porte undertook to find the funds required, and in 1856, soon after the assembling of the Commission, began to make the necessary remittances; these however came into the Commission's exchequer by small driblets —at irregular periods—and often after repeated applications only, and frequent disappointment of promised supplies.

The effect of such delays during important works may be readily conceived; materials and workmen had to be paid for regularly, *employés* could not be left unpaid, if honest service was to be given; and in a struggle with the unceasing forces of nature, works could not be suspended without great loss and waste.

Under these circumstances the branch of the Ottoman Bank at Galatz, the directors of which were English, advanced the necessary funds in 1860 to enable the Commission to complete the provisional works, to the extent of £30,000, on security of the dues to be raised from shipping; the terms were onerous —interest at 12 per cent. per annum, and a commission of 1 per cent. on the loan, but the service rendered to the Commission was very great—for without this money they would have had to discontinue the works just as success was within reach.

In 1862, the North German Bank of Hamburg made a loan of 800,000 marcs banco, at an interest of 6 per cent. per annum, and a commission of 5 per cent., paid in advance, also on security of the dues.

When the permanent works were decided on in 1865, a small loan of £10,000 was obtained from a London firm, through the influence of the British Commissioner, for current expenses, and negotiations were opened with the North German Bank for a large loan to carry them through, the dues being again pledged as above stated. The negotiations for the Hamburg loan were proceeding well, when they were brought to a close by the Austro-German war and the troubles which preceded it. By an arrangement with the Bank of Roumania at Galatz, the Commission was enabled to get through the difficulties thus caused, and on the recommendation of the British Commissioner, made an issue of bonds bearing interest at 10 per cent., redeemable at par in four years, for about £70,000, and secured by the dues. These bonds were taken up as issued, and the Commission was thus enabled to carry on the works of consolidation slowly during the year 1867.

In 1867, owing to the urgent representations of the British Commissioner backed by the Board of Trade, whose permanent secretary, Mr. (now Sir Thomas) Farrer, was keenly alive to the importance of the question, Lord Stanley (the present Earl of Derby) who was Secretary of State for Foreign Affairs, induced the Treasury to come to the aid of the Commission. This aid eventually took the form of a guarantee to a loan sufficient to complete the works, in which all of the Powers represented in the Commission, except Russia, joined. A practical shape was given to the guarantee by her Majesty's Government undertaking to be primarily responsible for the whole of any payments that might have to be made to the firm making the loan, and to recover from the other Governments their shares of such payments. This arrangement was embodied in a convention signed at Galatz on the 30th April, 1868, and ratified by an Act of Parliament in that year, called the Danube Works Loan Act. Under this guarantee the requisite funds were immediately obtained at 4 per cent., and a sinking fund established for the extinction of the loan in 1883. It is with some satisfaction that the author of this paper, who was largely responsible for this piece of finance, is able to state that the Government never had to advance a penny under this guarantee, and that the loan was paid off by the day stipulated. During the suspension of the trade, and consequently of the receipts at the mouth of the Sulina, in the Russo-Turkish war of 1877-78, the service of the loan was effected from the reserve fund that had been accumulated to meet a difficulty of this kind, or for the extension of works.

I must now say a few words on the tariff of dues which the Commission was authorised to raise to cover the expense of works and administration. In June, 1860, the Sulina provisional works were so far advanced, and had produced so much effect, as to justify the imposition of dues, whilst the entire cessation of remittances from Constantinople, and the refusal of other Governments to help, rendered it imperative on the Commission to employ the means at its command to get money to complete the works. A tariff of dues was therefore framed, and published in July, 1860, to take effect from the 1st September following.

The tariff was constructed on a double sliding scale, varying according to the size of vessels and the depth of the entrance. Vessels were classified according to their draught of water as represented by their tonnage, and the several classes were taxed according to the depth of water at the entrance.

The attached Table shows at a glance how this was effected, and that vessels did not pay for a greater depth than each required. A difference was also made between sailing ships and steamers, a per-centage of the gross tonnage of the latter being deducted and the vessels classed according to the resulting net tonnage. A further distinction was also made between ordinary traders and mail-packets bound to run on certain days whether laden or not.

TARIFF OF DUES ENACTED IN 1860.

Ships.	Amount of Dues to be paid per ton, with a depth at the Mouth						
	Of less than 10 ft.	Of more than 10 to 11 ft.	Of more than 11 to 12 ft.	Of more than 12 to 13 ft.	Of more than 13 to 14 ft.	Of more than 14 to 15 ft.	Of more than 15 ft.
	Frs. c.	Frs. c.	Frs. c.	Frs. c.	Frs. c.	Frs. c.	Frs. c.
Of more than 30 and of less than 100 tons	0·75	0·75	0·75	0·75	0·75	0·75	0·75
Of 100 tons at least and of 150 tons at most	1·0	1·50	2·0	2·0	2·0	2·0	2·0
Of more than 150 and not exceeding 200 tons.. ..	1·0	1·50	2·0	2·50	2·50	2·50	2·50
Of more than 200 and not exceeding 250 tons.. ..	1·0	1·50	2·0	2·50	2·75	2·75	2·75
Of more than 250 and not exceeding 300 tons.. ..	1·0	1·50	2·0	2·50	2·75	3·0	3·0
Of more than 300 tons..	1·0	1·50	2·0	2·50	2·75	3·0	3·25

Vessels taking cargo at Sulina and not ascending the river to the inland ports also paid a lower rate. The dues were levied on a vessel leaving the river, 25 per cent. being added if she entered laden with more than half cargo. This tariff also covered light dues and pilotage at the mouth, the only other due levied was for pilots between Sulina and the inland ports. The maximum due under this tariff was 3·25 frs. per ton, the minimum 75 centimes per ton. The original tariff of 1860 has been modified in amount several times since to suit the variations of trade; but throughout the guiding principle has been to make vessels pay according to the extent to which they are benefited by the works.

The Public Act of 1865 provided that there should be a revision of the tariff every five years in order to reduce it if possible; but it was not till 1880 that any great reduction could be made. Successive reductions taking effect in 1881, 1883, 1885, 1888, and 1890 have reduced the maximum toll to 1·90 fr., the minimum to 16 centimes per ton. No pilotage dues or increase of dues for entering as well as leaving the river laden are now levied. Under this tariff £1,718,860 have been raised from

GENERAL STATEMENT OF SHIPS LADEN WITH CARGO LEAVING THE SULINA MOUTH, FROM 1847 TO 1889.

Year.	Sailing Vessels.		Steamers.		Total.		Average Tonnage of the Year.			British.				British Total.	
										Sailing Vessels.		Steamers.			
	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	Sailing Vessels.	Steamers.	General.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.
1847 ...	2,027	240.911	36	9,012	2,063	249,923	118	250	121	—	—	—	—	151	22,614
1848 ...	1,296	178,841	35	8,641	1,331	187,482	138	247	1,0·8	—	—	—	—	133	21,248
1849 ..	1,641	243,420	35	10,557	1,676	253,977	147	301	151·4	—	—	—	—	132	21,843
1850 ...	1,449	210,231	40	12,594	1,489	222,825	145	315	149·6	—	—	—	—	108	17,709
1851 ..	2,102	298,753	52	10,567	2,154	309,320	142	203	143·5	—	—	—	—	306	54.064
1852 ..	2,422	347,443	54	19,425	2,476	366,868	143	359	148	—	—	—	—	343	62,540
1853 ...	2,450	325,207	40	11,660	2,490	336,867	132	291	135	—	—	—	—	205	35,241
1854 ...	680	112,707	—	—	680	112,707	166	—	165·7	—	—	—	—	45	7,840
1855 ...	2,919	495,015	9	1,851	2,928	496,866	169	205	169·6	—	—	—	—	—	—
1856 ...	2,110	318,004	101	20,193	2,211	338,197	150	199	152·9	—	—	—	—	161	32,046
1857 ...	1,797	235,301	141	39,747	1,938	275,048	130	282	141·9	—	—	—	—	168	28,912
1858 ...	2,358	299,322	150	44,806	2,508	344,128	122	298	137·	—	—	—	—	244	43,823
1859 ...	2,542	329,949	162	51,931	2,704	381,880	129	320	141	—	—	—	—	278	65,106
1860 ...	3,288	475,679	203	62,420	3,491	538,099	144	307	154	—	—	—	—	374	96,737
	29,081	4,110,783	1,058	303,404	30,139	4,414,187	—	—	—	—	—	—	—	2,648	509,723
1861 ...	2,845	391,642	239	59,128	3,084	450,770	137	247	146	214	55,278	35	12,928	249	68,206
1862 ...	2,807	397,593	208	52,425	3,015	450,018	141	252	149	212	61,468	16	8,983	228	70,451
1863 ...	2,845	450,085	254	69,247	3,099	519,332	165	271	167·5	216	57,545	31	15,988	247	73,533
1864 ...	3,259	536,653	189	49,241	3,448	585,894	164	260	169·9	247	76,523	34	10,701	281	87,224
1865 ...	2,479	389,565	197	52,664	2,676	442,229	157	267	165	180	52,316	33	11,839	213	64,155
1866 ...	2,221	358,176	210	69,273	2,431	427,449	161	325	175	186	55,387	55	27,292	241	82,679
1867 ...	1,713	314,231	247	79,789	1,960	394,020	183	327	201	189	58,920	84	35,536	273	94,456
Carried forward	18,169	2,837,945	1,544	431,767	19,713	3,269,712	—	—	—	1,444	417,437	288	123,267	1,732	540,704

Year.	Sailing Vessels.		Steamers.		Total.		Average Tonnage of the Year.			British.				British Total.	
										Sailing Vessels.		Steamers.			
	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.	Sailing Vessels.	Steamers.	General.	No.	Tonnage.	No.	Tonnage.	No.	Tonnage.
Brought forward	18,169	2,837,945	1,544	431,767	19,713	3,269,712	—	—	—	1,444	417,437	288	123,267	1,732	540,704
1868 ..	2,604	481,647	404	159,475	3,008	641,122	184	394	213	213	58,618	222	103,967	435	162,585
1869 ...	2,467	500,413	414	176,547	2,881	676,960	202	426	235	239	69,062	226	118,837	465	187,899
1870 ...	2,212	461,460	329	139,510	2,541	600,970	208	424	236	211	60,794	155	75,673	366	136,472
1871 ...	1,864	360,765	390	188,955	2,254	549,720	193	484	244	141	44,456	240	134,402	381	178,858
1872 ..	1,850	305,040	368	193,250	2,218	498,290	164	525	225	66	18,658	233	129,431	299	148,089
1873 ...	1,403	250,008	475	283,652	1,878	533,660	185	597	284	76	23,918	300	193,234	376	217,152
1874 ..	1,177	192,647	515	321,872	1,692	514,519	164	625	304	44	12,039	298	204,806	342	216,845
1875 ...	1,212	166,665	502	355,070	1,714	521,735	138	707	304	33	9,653	307	250,097	340	259,750
1876 ...	1,250	196,023	693	552,340	1,943	748,363	157	797	385	26	7,450	521	444,964	547	452,414
1877 ...	298	49,605	164	134,812	462	184,417	167	822	399	18	4,312	134	115,390	152	119,702
1878 ...	1,162	164,316	700	535,847	1,862	700,163	141	765	376	24	6,198	483	411,598	507	417,796
1879 ...	1,541	238,526	721	559,028	2,262	797,554	155	775	353	15	4,214	479	408,492	494	412,706
1880 ...	1,227	189,553	586	468,510	1,813	658,063	154	799	363	9	2,543	362	329,715	371	332,258
1881 ...	941	140,438	770	653,016	1,711	793,454	149	848	464	7	2,328	516	496,666	523	498,994
1882 ...	804	116,627	842	786,436	1,646	903,063	145	934	549	3	1,224	580	607,219	583	608,443
1883 ...	637	81,235	807	750,251	1,444	831,486	128	931	576	—	—	532	549,942	532	549,942
1884 ..	515	69,548	663	628,118	1,178	697,666	137	944	592	—	—	422	448,990	422	448,990
1885 ...	641	103,437	791	792,387	1,432	895,824	161	1,001	626	—	—	543	584,525	543	584,525
1886 ...	506	82,551	873	868,016	1,379	950,567	163	994	689	4	1,269	564	622,201	568	623,470
1887 ...	607	104,709	1,071	1,098,975	1,678	1,203,684	172	1,026	711	—	—	720	796,360	720	796,360
1888 ..	563	92,562	1,208	1,240,345	1,771	1,332,907	164	1,026	754	—	—	823	947,533	823	947,533
1889 ..	555	89,481	1,315	1,383,864	1,870	1,473,345	143	1,052	788	—	—	842	1,000,773	842	1,000,773
Total ...	44,205	7,275,201	16,145	12,701,043	60,350	19,977,244				2,573	744,173	9,790	9,098,087	12,363	9,842,260

TARIFF RECEIPTS.

Value.	Francs. c.	Year.	Francs. c.
1860	256,583·12	1876	2,124,688·47
1861	855,387·78	1877	474,247·06*
1862	844,845·16	1878	2,031,766·37
1863	1,048,263·39	1879	2,198,053·29
1864	1,240,540·84	1880	1,800,699·70
1865	747,813·74	1881	1,985,051·94
1866	882,697·30	1882	2,231,087·37
1867	880,298·37	1883	1,710,665·61
1868	1,616,869·07	1884	1,433,572·83
1869	1,699,427·98	1885	1,442,114·36
1870	1,507,535·01	1886	1,593,695·67
1871	1,417,084·25	1887	1,914,581·28
1872	1,281,339·94	1888	2,077,110·06
1873	1,409,404·35	1889	1,348,552·10
1874	1,356,075		
1875	1,361,453·17	Total..	42,971,504·58

shipping in the twenty-nine years and four months from 1st September, 1860, to 31st December, 1889. The money thrown into the sea in 1858-60 has been well recovered.

I give two Tables, one (pp. 576-7) showing the movement of the navigation from 1847 to 1889 inclusive, the other the amount levied annually under the tariff (above). It will be seen that although the tonnage has increased enormously during the last decade, having nearly doubled in that time, the amount raised from dues has remained stationary till last year, owing to the reduction of tariff during that period. The tonnage table shows great fluctuations from year to year, as, the bulk of the trade being in grain, its amount depends on the harvest in Roumania and part of Bulgaria. I also append a Table (p. 579) constructed by Sir Charles Hartley, showing at a glance the movement of the navigation from 1856 to 1889.

The effect of the works carried out by the Commission in providing an easy and safe channel for the exports of the country may be gauged by the following comparisons. From 1847 to 1860, the year before a deepened entrance was given to navigation, the trade increased:—From 2,063 vessels of 249,923 tons, average per ship 121 tons, to 3,491 vessels of 538,099 tons, average per ship 154 tons. The number of shipwrecks at the mouth of the Sulina, from 1856 to 1860, was 62 or 39 per 10,000 of vessels frequenting the river, whilst from 1861 to 1889, that is since the entrance was deepened, there have been only 33 wrecks, or 5 per 10,000, and the navigation has increased to 1,870 vessels, of a tonnage of 1,473,345 tons, the average per ship being 788 in the year 1889.

Since the consolidation of the piers and establishment of an equilibrium between the contending forces of the river and the sea, as shown by the maintenance of a constant depth in the entrance of 20½ feet, Sulina has become a port of refuge to vessels in distress. From 1873 to 1886 inclusive, 503 vessels took refuge in the port, and left again without transacting any business, the condition under which they would pay no dues.

The increase of trade at the mouth of the Danube is shown by the tonnage returns above given. The benefit that shippers have realised since 1861, from not having to pay for lightening their ships over the shoals, may be estimated at a moderate computation at £5,000,000, whilst the gain from the use of larger and more seaworthy ships, from the possibility of employing powerful steam vessels in place of small sailing vessels, and the consequent regularity and speed of arrival of cargoes at their ports of destination, must be valued at a further considerable sum.

The political and social changes through which Roumania and Bulgaria have been passing during the 34 years that the European Commission of the Danube has been at work, have certainly led to the rapid development of these countries and to the expansion of their productive powers to which the figures given bear testimony. It does not, however, seem too much to say that these changes would not have told so quickly if the means of profiting by increased production through the facilities given for the export trade had not been provided by the opening of the Danube.

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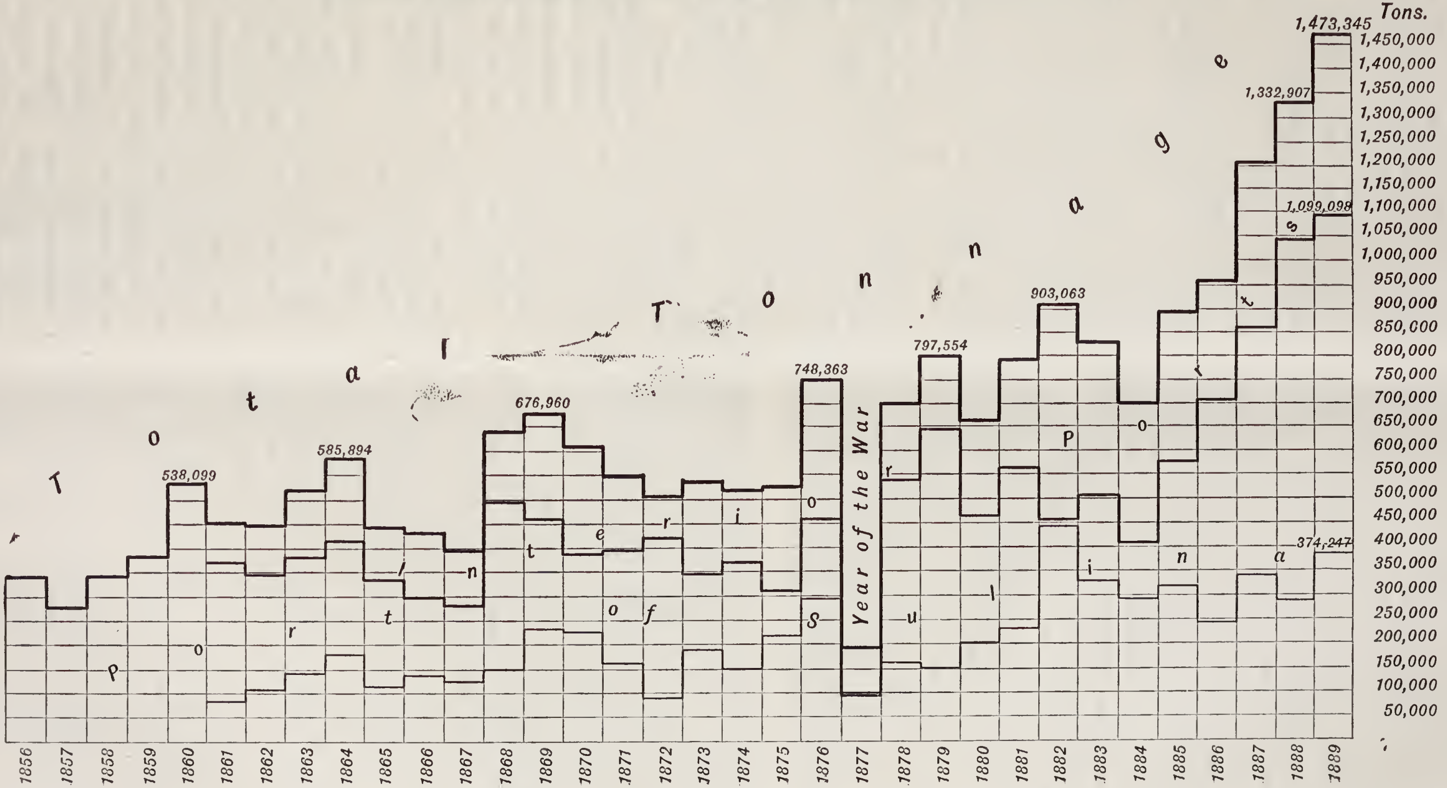
* Year of the Russo-Turkish War.

INCREASE OF TOTAL TONNAGE OF LOADED VESSELS LEAVING THE SULINA MOUTH OF THE DANUBE, AND OF VESSELS LOADED AT THE INTERIOR PORTS OF THE RIVER AND AT THE SULINA PORT, FROM 1856 TO 1889.



As regards the effect on English trade, Consul Cunningham reported that prior to 1847 only from 3 to 52 English vessels entered the Danube yearly; from 1847 to 1860, 2,648 English vessels of a tonnage of 509,723 tons traded there; and from 1861 to 1889 inclusive the British flag was represented by 12,363 vessels measuring 9,842,260 tons of net tonnage; thus the average annual amounts of 189 vessels of 36,409 tons in the first period increased to 426 vessels of 339,388 tons in the second period, or more than ninefold as regards tonnage. In 1889 British tonnage formed 67·9 per cent. of the whole trade, and British ships have paid from 71·6 to 82·3 per cent. of the dues levied during the last nine years.

The transformation of the British sailing tonnage into steam tonnage is very remarkable, for whereas in 1861 the British totals were made up of 214 sailing vessels, with a tonnage of 55,278 tons, and 35 steam vessels of 12,928 tons, in 1889 there was not a single sailing vessel, but 842 steamships, measuring 1,000,773 tons. For the last seven years, six have shown no British sailing vessels on the returns, the exception being in 1886, when there were four.

In the foregoing I have confined my remarks principally to the engineering problems of the Commission, and to the effect on trade produced by the works, but I must not omit all reference to the other side of the Commission's work—the suppression of the many evils under which trade suffered from the lawlessness of the floating population of the Delta.

Regulations were enacted at once to control the pilots and lightermen, and to establish a police of the river; but the jealousies of the territorial Power and its neighbours retarded for some time any efficient administration of the Commission's enactments, the very power to make them being contested by some, doubted by others. The only coercive action possessed by the Commission lay in the co-operation of the light vessels, two of which each of the seven Powers had the right to station in the Danube, under Art. XIX. of the Treaty of Paris. These vessels had no collective action, but their commanders were instructed to aid their respective Commissioners in the performance of their duties. Unquestionably, the knowledge that the Commissioners had this force behind them prevented any overt resistance to their administration, though as the naval officers could not act as agents of police, the enforcement of the regulations in detail was exceedingly difficult, until the Commission felt itself in a position to appoint agents of its own to compel obedience by the infliction of fines. In 1861, an Inspector-general of the navigation was appointed, with agents under his orders. The latter had each a section of the river to visit daily, and report on infractions of the regulations, which the Inspector-general punished by fines. Vessels were not allowed to leave the river till these fines were paid.

The Public Act, which was ratified in 1866 by all the Powers, thenceforward became the law of the Danube, which the Commission administered. To it were annexed a Navigation Law and Tariff Regulation, which embodied, in a revised form, all the provisional regulations and tariffs enacted by the Commission since its institution. The functions of this body thus became very comprehensive, for in addition to its executive powers, by which it carries out works and levies revenue, it is a legislative body enacting laws, which it administers by its own agents, and it is, further, a final court of appeal to adjudicate on the complaints made against the decisions of the Inspector-general.

It speaks well for the impartiality and justice with which the Commission has rendered judgment, that during the twenty-four years that have passed since this court was established, no complaint has been raised.

In fact, it may be stated without fear of contradiction, that the European Commission introduced into every branch of its administration a high standard of action entirely unknown in those countries before its arrival.

Works have been carried out without peculation; workmen and *employés* generally have been paid regularly; contracts have been loyally adhered to, and abuses of every kind vigilantly repressed.

Reference has been made at the beginning of this paper to the creation of a a Riverain Commission, which was eventually to succeed to the duties and powers of the European Commission. This body met in 1856-7 and framed a Navigation Act, but this instrument gave rise to so many objections, and the relations between the greater Powers and the smaller States traversed by the river and claiming to be represented in the Commission, were so strained, that the Riverain Commission never afterwards met for any practical purpose. Its existence has been recognised from time to time by diplomatic conferences, notably in the Treaty of London in 1871, and again in the Treaty of Berlin in

1878, but it has never carried out any practical work either in the way of regulating the navigation or improving the river. The Congress of Berlin, in 1878, invested Austria-Hungary with the right of executing works between Old Moldova in Hungary and Turna Severin in Roumania, and with authority to levy dues to defray the cost of the works. The great problem in engineering which has to be solved in this section of the river is that of giving a navigable channel at all seasons through the dangerous rapids known as the Iron Gates, just below the town of Orsova at the point where the Danube emerges from the Carpathians into the plains of Roumania and Bulgaria. This has been a vexed question for the last 30 years, and has been studied by engineers both of Europe and America. I believe that blasting operations have been begun by the Austro-Hungarian Government, but I do not know on what plan.

The bulk of the Danube trade consists of grain—wheat, barley, and Indian corn taking the first place, oats, rye, millet, rape, and linseed following at a long distance. Other exports are petroleum, tallow, salt fish, hides, wine and spirits, cheese, planks, timber, and wool. The imports are machinery, coals, bar and sheet iron, and articles of clothing.

The countries bordering on Roumania and Bulgaria being also agricultural, and their products identical, the exports of these countries by the Danube descend the river, except on rare occasions; but the imports are derived from Austria-Hungary and Germany, as well as from Great Britain. The imports from Austria-Hungary are mostly carried down the river in the flotillas of iron barges belonging to the Imperial and Royal Steam Navigation Company, which have their head-quarters at Pesth.

In conclusion, a word ought to be said with

STATEMENT SHOWING RECEIPTS FROM BRITISH SHIPPING, 1863 TO 1889.

Year.	Receipts from Sailing Vessels.	Receipts from Steamers.	Total Receipts in Francs.	Total Receipts in Sterling.	Total Receipts from all Nations.	Per centage paid by British Ships.
	frs. c.	frs. c.	frs. c.			
1863			562,517·72	5,933	41,930	14·1
1864	176,920·66	25,358·68	202,279·34	8,091	49,621	16·3
1865	135,506·24	13,953·98	149,460·22	5,978	29,912	19·9
1866	146,534·06	55,902·49	202,436·55	8,097	35,304	22·9
1867	152,389·20	96,597·72	248,986·92	9,959	35,212	28·2
1868	168,428·33	299,378	467,806·33	18,712	64,674	28·9
1869	187,670·18	368,956·87	556,627·05	22,265	67,977	32·7
1870	187,707·11	209,304·14	397,011·25	15,888	60,301	26·3
1871	133,455·87	429,061·85	562,517·72	22,500	56,683	39·6
1872	58,208·90	440,769·35	498,978·25	19,959	51,253	38·9
1873	69,180·85	615,056·47	684,237·32	27,369	56,376	48·5
1874	34,396·83	657,370·12	691,766·15	27,670	54,243	51·0
1875	29,268·97	755,559·15	784,828·12	31,394	54,459	57·6
1876	25,473·47	1,392,998·05	1,418,471·52	56,739	84,987	66·7
1877	5,894·76	341,013·86	346,908·62	13,876	*18,969	73·0
1878	19,946·82	1,366,114·83	1,386,061·65	55,442	81,270	68·2
1879	14,263·77	1,293,275·36	1,307,539·14	52,301	87,922	59·4
1880	7,698·90	1,031,182·27	1,038,881·17	41,555	72,028	57·6
1881	6,456·22	1,428,249·53	1,434,705·75	57,344	79,402	72·2
1882	3,292·37½	1,652,584·76	1,655,877·13½	66,235	89,243	74·2
1883	*nil.*	1,258,803·15	1,258,803·15	50,352	68,426	73·5
1884	*nil.*	1,037,633·15	1,037,633·15	41,105	57,343	71·6
1885	*nil.*	1,068,744·47	1,068,744·47	42,349	57,644	73·4
1886	253·80	1,170,351·81	1,170,605·61	46,824	63,747	73·4
1887	*nil.*	1,479,518	1,479,518	59,180	76,583	77·2
1888	674·79	1,710,168·44	1,710,743·23	68,429	83,084	82·3
1889	*nil.*	1,036,452·88	1,036,452·88	41,458	53,942	76·8

* Year of the Russo-Turkish War.

reference to the duration of the beneficent control exercised by the European Commission of the Danube, and as to the status of the jurisdiction confided to that body in time of war.

The term fixed by the Treaty of Paris was stated tentatively at two years, at the end of which time the Commission was to have completed its task, and its duties were to devolve on the Riverain Commission.

It was, however, soon found that this term was founded on a misconception, and it was successively extended by periods of five or six years, until at the London Conference of March, 1871, it was definitely extended to April, 1883.

In 1883, however, owing to the changes that had been introduced into the political *régime* of the Danube, in 1878, when the Russian frontier was advanced to the Kilia, and the Sulina mouth passed into the hands of Roumania, a new Treaty between the seven Great Powers was signed and ratified in London. By it it was agreed that the term of the Commission's functions should be extended to 1904, and that thenceforward the Commission should remain in existence until the Powers should arrive at an understanding for its dissolution, which may be read to mean, *extensio in perpetuo,* whilst its jurisdiction was extended to Ibraila.

This Treaty also adopted a regulation for the government of the navigation from the Iron Gates to Ibraila.

The Treaty of London, of March, 1871, provides for the neutrality of the Danube works, and of the staff and *employés* of the Commission during war.

The Treaty, however, reserved to Turkey, as at that time territorial Power, the right to send light vessels of war into the river. This led to a certain infringement of the neutrality clauses by Russia in 1877, when the Russian commanders made a dam across the Sulina branch, to prevent Turkish vessels of war ascending the river to interfere with their communications, and as a Turkish fleet lay in the Sulina Roads, some Russian vessels descended the river and opened a slight bombardment on Sulina. Their shells, however, did no damage to the works, and after peace was concluded, the Commission's engineers soon removed the dam, and no permanent injury was done to the river. As Turkey no longer holds the mouths, in any future war there will be no pretext for this action, if Roumania is neutral.

The Powers represented in the European Commission of the Danube were, in 1856—Great Britain, Austria, France, Prussia, Russia, Sardinia, and Turkey. They are now—Great Britain, Austria-Hungary, France, Germany, Italy, Russia, Roumania, and Turkey.

The British Commissioners have been Major Stokes, R.E. (now Lieut.-General Sir John Stokes, K.C.B.), August 1856, to December, 1871; Colonel C. G. Gordon, R.E., C.B.* December, 1871, to November, 1873; Colonel (now Major-General) H. T. Siborne, R.E., November, 1873, to 1881; Percy Sanderson, Esq., C.M.G., since 1st January, 1882.

DISCUSSION.

The CHAIRMAN having invited anyone present to put questions with regard to points on which further information was desired, several questions were asked, in reply to which,

Sir JOHN STOKES said that vessels of 2,000 tons could now go up to Ibraila. The obstruction to the navigation which was interposed during the military operations to which he had referred, consisted of a dam across the Sulina which prevented vessels going up; though sufficient space was made for the ships of war to go down. There was great apprehension felt that this dam would materially injure the river by creating shallows below, but happily there was not a very heavy flood, and no great harm was done; at any rate it was soon remedied. Iron, machinery, and other heavy goods went up the river as far as Ibraila, and were from thence mainly conveyed to their destination by rail; when they were going to any place higher up the river they might be forwarded by barges.

The CHAIRMAN said he had now to perform the very agreeable duty of proposing a hearty vote of thanks to Sir John Stokes for his exceedingly able and interesting paper. A more clear and distinct account of an excessively difficult undertaking, begun, planned, and carried out to completion in the face of almost every conceivable obstacle it was impossible to conceive. He had been particularly struck with the account given of the great difficulty experienced by the Commissioners in carrying out what was at first intended only as a small scheme for improving the Sulina mouth, but which was afterwards developed into a plan for making it the main entrance to the river instead of the St. George's Channel. When one considered the amount of opposition, and the high character of that opposition, it showed a self-reliance and determination on the part of the engineers, and of those Commissioners who supported them, which was very remarkable, and deserving of the greatest commendation. He hoped that the late

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* Better known for his exploits in China and the Soudan.

Prime Minister of Servia, whom he was very glad to see present, would second the resolution.

His Excellency CHED. MIJATOVICH said he considered it a great honour to be allowed to second the vote of thanks. No one present could have been so much interested in the paper as himself, coming from a Danubian country, and in fact he had found it the most interesting paper he had ever heard. Sir John Stokes had narrated very clearly what had been accomplished by the Commissioners, but he had not dwelt much on the difficulties which had to be encountered; but as he had the honour of representing Servia at the Conference of 1871 in London, on the Danubian and Black Sea question, it necessitated his making himself acquainted with the working of the European Commission on the Sulina, and he was much struck with the difficulties which presented themselves, and with the small amount of faith in the success of the undertaking which was displayed by the Great Powers. Sir John, however, could well afford to forget the difficulties experienced at the beginning, in view of the magnificent results which had been attained. He hoped the River Danube, which from the time of the Emperor Trajan up till now had been mostly known in connection with war, and the crossing and re-crossing of great armies, would in future be more connected with the progress of civilisation, and with the commerce which the engineering arts had now rendered possible. If there was one country in the world more than another which should be glad to aid in this great work it was England. That, however, was for Englishmen to judge, but he might be allowed to say this—that England could not desire a better representative in such a work than Sir John Stokes.

Sir C. RIVERS WILSON, K.C.M.G., said he should like to briefly support the motion by pointing out that Sir John Stokes's services to the country did not cease with his labours on the European Commission, but owing to the experience he then gained, his assistance in connection with the Suez Canal had been very valuable. He was able to speak with great authority on behalf of and to the Government on all technical questions connected not only with engineering matters but with the passage of ships through the canal, and especially on the settlement of that vexed question, the assessment of the tonnage of vessels. As most persons present were aware that was a question which gave rise to the greatest possible discussion, and to international difficulties, and he knew of his own knowledge that it was chiefly owing to Sir John Stokes's exertions and great knowledge, and especially to the weight of his experience gained on the Danube, that that vexed question was able to be settled, as the result of the Conference held at Constantinople, in which he took a leading part. From the time when Sir John Stokes severed his connection with the Danube, he had devoted a great deal of his time, attention, and talent to the Suez Canal, and had rendered great services to the Government and the country.

The vote having been passed unanimously,

Sir JOHN STOKES said he felt overwhelmed by the kindness with which his paper had been received; he could only say that in connection with the Danube, as in other matters, he had tried to do his duty to the best of his ability.

NINETEENTH ORDINARY MEETING.

Wednesday, April 30th, 1890; Captain W. de W. ABNEY, C.B., F.R.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Benest, Edward Everett, 38, Glebe-road, Bromley, Kent.
Fry, Albert, 8, Cambridge-park, Redland, Bristol.
Thomason, William, Messrs. Doulton and Co., St. Helens, Lancashire.
Thomlinson, William, Seaton Carew Iron Company, West Hartlepool.
Vaughan, R. Wyndham, 64, Broad-street-avenue, E.C.

The following candidates were balloted for and duly elected members of the Society:—

Barry, James H., 110, Cannon-street, E.C.
Blakely, William, Vernon, Bournemouth West.
Browne, Andrew, 13, Fenchurch-avenue, E.C.
Burnett, Robert, 47, Carden-place, Aberdeen.
Denny, Archibald, Leven Ship-yard, Dumbarton, N.B.
Herschell, Lord, 46, Grosvenor-gardens, S.W.
Joseph, Major Hymen Aron, Rutland-house, 45, Aberdeen-park, Highbury, N.; and Junior Carlton Club, S.W.
Lindo, Gabriel, 36, Orsett-terrace, Hyde-park, W.
Storr, Walter W., 3, Victory-terrace, Redcar.
Wilson, Henry J., M P., Osgathorpe-hills, Pitsmoor, Sheffield.

The paper read was—

PHOTOGRAPHIC LENSES.

BY THOMAS R. DALLMEYER.

Photographic lenses in general are optical systems for the formation of real images. The perfection of the image, its exact resemblance to the object, and its distinctness, will depend on the exact conveyance of all the rays of pencils emanating from every point in the object into strict mathematical points in the image, or the nearest approximation to such points as may be. If aberration is present due to improperly chosen curvatures or improperly combined materials, the resulting image will lose in its distinctness, and may become useless. The object, then, in constructing lens systems is the best possible destruction of aberrations both chromatic and spherical. With this in view we have to consider, first, the proper selection and perfect homogeneity of the materials employed; secondly, the best selection of curves ascribed to the material; and thirdly, mechanically, a strict maintenance of the "figure" (as it is technically termed) of the curves when the material is properly polished. As it will not be possible in the time allotted to this paper to touch on the mechanical processes employed, I will mention here that this, of course, is a very important consideration.

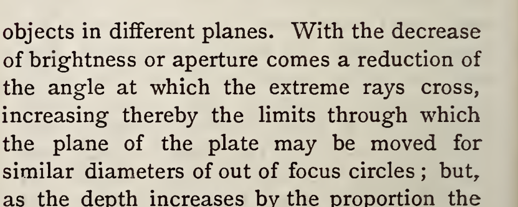
Glass is a very perfectly elastic substance, and if in the processes of sticking the glass on to polishers the material becomes "biassed," however perfectly the curve may then be polished, the glass on being released from the polisher will spring back, and the true curve will no longer be maintained, and will give rise to an unexpected appearance in the image technically termed "un-natural" aberration. Similar effects occur from bad workmanship in polishing, the polish not being distributed equally. Such defects are quite inadmissible, for although not visible by ordinary reflexion, the polish appearing very good, a critical examination of the image will show the deleterious effect.

In the application of photographic lenses for ordinary purposes, we ask the instrument to do practically what is theoretically an impossibility. An imaginary perfect lens can only truthfully depict one plane at a time, every other plane being out of focus; when, however, the lens is used under conditions that all rays coming from points in the object are so situated that they are practically parallel, or the circles of confusion in the plane of the image, when removed from the plane for parallel rays, are so small that they are undistinguishable from points visually, the general appearance is one of uniform sharpness. In ordinary lens construction the rays are usually considered as parallel, but in large portrait lenses the means should be given, if sharp images are the theoretical desideratum, of correcting the spherical aberration introduced for nearer planes.

There are great advantages, you will be aware, from rapid lenses or brilliant images. Herschel points out that the brightness of an image is proportional to the quantity of light which is concentrated in each point of it; and, therefore, supposing no aberration, as the apparent magnitude of the lens which forms it, seen from the object $\times \dfrac{\text{area of object}}{\text{area of image}}$. Or since the area of the object : that of the image : : (distance)^2 of object from lens : (distance)^2 of image; and since the apparent magnitude of the lens seen from the object is as its $\left(\dfrac{\text{diameter}}{\text{distance of object}}\right)^2$, the brightness or degree of illumination of the image is as the magnitude of the lens seen from the image alone, whatever be the distance of the object. Now the apparent magnitude of the lens seen from the image is always much less than a hemisphere. Therefore (leaving out the loss of light by reflection and refraction), the brightness of the image is always much less than that of the object.

I mention these facts at the outset, for the reason that you may clearly understand that it is quite impossible for the lens, with a large ratio of aperture to focus, or one that aims at attaining a maximum brightness of image (such as are used in portraiture), also to maintain at the same time the uniform qualities above referred to in a lens, the ultimate employment of which is to depict, with sufficient exactitude or definiteness, objects in different planes. With the decrease of brightness or aperture comes a reduction of the angle at which the extreme rays cross, increasing thereby the limits through which the plane of the plate may be moved for similar diameters of out of focus circles; but, as the depth increases by the proportion the diameter of the lens is diminished or stopped down, the brightness decreases as the square of the intensity ratio, or the ratio or aperture to focus.

Fig. 1.



As the ultimate applications of various

optical systems are at the outset understood, a knowledge of geometry and analysis will enable the optician to construct different forms that shall be particularly suited to the end to be attained.

I take it for granted that you are all acquainted with first principles and first approximations in the refraction of light at plane and spherical surfaces, and are familiar with the fact that the different coloured rays of which white light is composed are unequally refracted in their passage through a refracting medium, giving rise to chromatic aberration.

As stated before, our effort is, as far as possible, to destroy in the final image of every system the aberrations arising from the spherical forms of the lenses and from chromatic aberration. The process necessary to destroy the latter being the easier defined, we will approach it first, and return to the headings.

I.—The Proper Selection of Materials.

It is well known and easily demonstrated that a single lens cannot be made free from either spherical or chromatic aberration for parallel rays. (A study of the different forms of single lenses and their adaptability to different photographic purposes is very interesting and instructive, and we will run through them briefly when on the subject of spherical aberration.) If, however, we combine two or more lenses of different media, we have the means of annihilating both aberrations simultaneously. The elimination of chromatic aberration is rendered possible by the property of refracting substances of dispersing colours in a very unequal degree, though the difference in the refractive power is comparatively slight.

Taking the D line of the spectrum as brightest visually, and the G or H line as that of the most chemically active rays, in order that a lens may be of value in photography (or be actinic) it is most essential that these lines be combined, whatever may become of the rest. Thus two lines can be combined with two different kinds of glass, and n lines may be of course combined by employing n different kinds of glass.

For example, take Chance's ordinary hard crown glass, the refractive index for line D = 1·517116, and for the line G, 1·528348; for dense flint, for line D, 1·622411, and for line G, 1·646071. The difference, then, between these lines is, for the crown glass, ·011232, and for the flint, ·023660. The dispersive power of the flint between these particular lines is more than twice as great as that of the crown.

Now, you know that if a number of lenses are placed in contact (supposed infinitely thin), the focus or convergence of the system is equivalent to the algebraical sum of the components of the system. It can be shown for two kinds of glass, such as the above; the chromatic aberration can be destroyed, or actinism (the coincidence of chemical and visual foci) be maintained; the glasses must be unequally dispersive, one convergent or positive, and the other divergent or negative. The system can be made free from chromatic aberration, and convergent if the lens formed of the less dispersive power is positive, and is divergent if the lens formed of the less dispersive power is negative. In every case the ultimate rays from the lens converge to form a real image, so that (unless in the lens-system a negative element is introduced as a corrector) it will be found the positive element is always composed of the less dispersive medium.

Recent improvements in glass manufacture necessitate the expressions of "positive" and "negative" elements in lens systems, instead of the flint and crown, and to these I am about to refer. My late grandfather, in a paper contributed to this Society on "Practical Illustrations of the Achromatic Telescope," says of glass then known:—"The flint is easily distinguished from the crown by its superior specific gravity, arising from the quantity of lead which enters into its composition. Thus the glass which is called flint glass has, in fact, a smaller proportion of silica than crown. It obtained this title from the care employed in selecting the flint with a view to the purity of the glass, and the term has since become so extensively adopted as to be now almost European." Again, "Discs of homogeneous flint glass, more than four or five inches in diameter, are exceedingly rare and very costly." The advances in the art of glass-making have been very great since that time. By the skill and enterprise of Messrs. Chance, of Birmingham, Pfeil, of Paris, and most recently the elaborate work of Professor Abbe, assisted by Messrs. Schott and Gen, of Jena, the means at the optician's disposal is now placed in a much more satisfactory position.

In this country much valuable work has been accomplished by Dr. John Hopkinson and Professor Stokes, in obtaining convenient methods of expressing the measure of the irrationality of combinations of various glasses made by Messrs. Chance, of Birmingham. Dr. Hopkinson contributed a very important paper, important especially to opticians, on this subject to the Royal Society in 1877, and in conjunction with my late father, worked out some important and valuable improvements in glasses for special photographic purposes, and succeeded in practically curing several of the glasses then made from "sweating." Sir Gabriel Stokes, too, suggested a titano-silicic crown that should be perfectly achromatic with a flint; this glass, however, was not found to be of much practical value. To express the irrationality, Dr. Hopkinson found a convenient formula that more accurately represented the facts from observations than the direct method of curve drawing, as the errors in this case would be greater than those of observation. I refer those interested to the paper, but give you the results of that formula, which serve to show how little there was to choose between the ordinary glasses made by Messrs. Chance. The figures show the measure of irrationality in a combination of each combined with a standard :—

Hard crown.	Soft crown.	Titanic crown.	Light flint.	Dense flint.	Extra dense flint.	Double extra flint.
−11·7	−10·7	−9·4	−9·4	−11·8	−11·9	−13·2

It will be interesting to compare some of the new glasses from Jena with these; and although they are presented in a less elegant form, the prospectus is a very practical representation of the qualities of the glasses, so I give the data of Chance's glasses in a similar form to those of Jena; but we will first make a preliminary investigation as to the conditions to be arrived at.

The dispersion, then, of colour produced by a positive or convex lens, may be neutralised by the addition of a negative or concave one, without cancelling the deviation of the rays, as the positive and negative lenses act with opposite effect. In other words, a compound lens may, by the proper adjustment of the *powers* of the separate lenses, be made achromatic or actinic, although if irrationality in the dispersions exists, only the union of a definite number of species can be combined, according to the number of different media forming the compound lens.

If the radii of a lens are r and s, in general approximation, $\frac{1}{f} = \left\{\mu - 1\right\}\left\{\frac{1}{r} + \frac{1}{s}\right\}$

Herschel terms the reciprocal of the focal length the *power* of a lens, and this is seen to depend on $(\mu - 1)$, which we may take as the measure of the refracting power of the substance of which the lens is composed, and the second $\left\{\frac{1}{r} + \frac{1}{s}\right\}$ the simplest measure of the joint curvature.

To determine the relation between the focal lengths of two lenses that shall be achromatic or actinic when in contact :—

Let $\frac{1}{\rho}$ represent $\left\{\frac{1}{r} + \frac{1}{s}\right\}$ and μ_1 μ_2 the indices of refraction for the two lenses for one species of rays.

Then if u be the distance from which the pencil originally diverged,

$$\frac{1}{v_2} = \frac{\mu_1 - 1}{\rho_1} + \frac{\mu_2 - 1}{\rho_2} - \frac{1}{u}$$

and similarly, if μ' represent the index of refraction for another species of rays,

$$\frac{1}{v_2} = \frac{\mu'_1 - 1}{\rho_1} + \frac{\mu'_2 - 1}{\rho_2} - \frac{1}{u}.$$

As v_2 is to be the same for both species, we get by subtraction, term by term and representing $\mu' - \mu$ by $\Delta\,\mu$, we have

$$\frac{\Delta\,\mu_1}{f_1} + \frac{\Delta\,\mu_2}{f_2} = 0, \text{ or } -f_2 = f_1 \frac{\Delta\,\mu_2}{\Delta\,\mu_1}.$$

Now in general $f = \frac{\rho}{\mu - 1}$;

$$\therefore\ -f_2 = f_1 \cdot \frac{\Delta\,\mu_2}{\mu_2 - 1} : \frac{\Delta\,\mu_1}{\Delta\,\mu_1 - 1}.$$

Therefore the focal length of lenses are directly, or their powers inversely, as the dispersive powers of the media of which they consist.

$$\text{Again, since } \frac{1}{f} = \left\{\mu - 1\right\}\left\{\frac{1}{r} + \frac{1}{s}\right\},$$

$$\Delta\,\mu \frac{1}{f} = \left\{\frac{1}{r} + \frac{1}{s}\right\},$$

$$= \frac{\Delta\,\mu}{\mu - 1} \cdot \frac{1}{f}.$$

That is to say, the chromatic variation of the power of a lens is obtained by multiplying it by the dispersive power of the medium,

$$\text{or } f_1 : -f_2 :: \frac{\Delta\,\mu_1}{u_1 - 1} : \frac{\Delta\,u_2}{\mu_2 - 1} \ldots\ldots(1).$$

In like manner by adding a third species of glass we can satisfy a third condition, viz., that the third species should be united to the two former. And in general

$$\Delta\mu \,.\, \frac{1}{f_1 f_2 \cdots f_n} = n \, \frac{\Delta\mu}{\mu - 1} \,.\, \frac{1}{f_1 f_2 \cdots f_n}$$

The prospectus published by the Laboratory at Jena is presented in a very practical form to opticians; the refractive index for the brightest line D being given, and the differences of the refractive indices for the four intervals, CF, A′D, DF, and FG′. The interval CF (containing the brightest portion) is sufficient to characterise the medium dispersion, and from the proportion of this to the value $\mu_D - 1$ there is given in a separate column the reciprocal of the relative dispersions or of $\left\{\frac{\Delta\mu}{\mu - 1}\right\}$. The proportion of partial dispersions in the intervals A¹D, DF, FG′, are a sufficient guide to judge of the possibilities of successful combinations for achromatism. There are also given the numbers obtained by dividing these intervals of partial dispersion by the amount of medium dispersion for the interval CF, and a comparison of these quotients will show the tendency and amount of the residual secondary spectrum. The identity of corresponding quotients proves the possibility of achromatising without secondary colour.

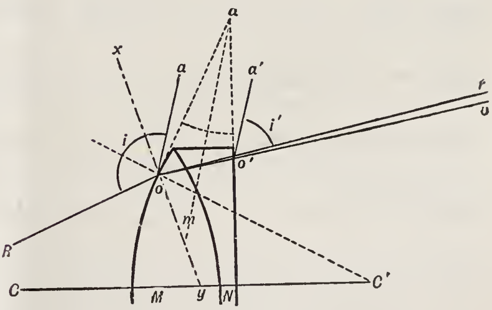
In the older products of glass factories it was quite sufficient to take the specific gravity of the various glasses, as a near approximation to any alteration in the optical properties of different meltings: a greater density indicating an increase of refractive index and dispersive power.

The figures in the list, taken from the prospectus from Jena, show that glasses are made of nearly equal relative dispersion, with considerable differences in partial dispersion, and, again, others in which the partial dispersion is almost identical, with considerable variation in the relative dispersion. In those instances it is evident that the secondary spectrum can be abolished. There is, however, a residual tertiary spectrum in the couples referred to, but it is quite unimportant compared to the secondary spectrum left in a combination of ordinary silicate "crown" and "flint" glasses. In photographic lenses the object is to get all the chemically and visually active rays possible together, and with certain of the glasses of lower dispersion, improvements may yet be made by a better correction, both in the chromatic and spherical aberrations of the excentrical pencils in lens systems.

The first approximations in theory, both for aplanatism and actinism, are simple enough when the lenses of the systems are considered *thin*, and second approximations, for the central pencils, are given in most of the text-books in which *thickness* is taken into account, and are easily intelligible. In lenses required to be both aplanatic and actinic, we are not limited only to the central pencils, and it is of the highest importance that all incidences for the lens should give the same results as the central pencils, and it is the inquiry into the forms best suited to accomplish this that constitutes the optician's great difficulty.

As a matter of fact it is impossible to construct an aplanatic lens that is free from chromatic aberration, for a central pencil that shall be so when a pencil of rays meet the lens obliquely. Lenses may be considered as made up of an infinite number of prisms, and, as you are aware, achromatism is only possible with combined prisms for one particular incidence. Now a parallel ray and an oblique ray must of necessity have different incidences on the surface of a system, and hence, if it is actinic for the parallel ray, it cannot be for the oblique ray strictly speaking.

FIG. 2.



Let us examine a case geometrically for a parallel ray and an oblique ray. For simplicity take an equi-convex lens achromatised by a concave-plane one, and trace the course of these rays through the combination. The ray, R, parallel to the axis, and the ray R¹, incident obliquely to the axis, may be considered as passing through the same prism, the angles

Kinds of Glass.	Refractive Index for D.	Medium Dispersion C to F.	$\frac{\mu - 1}{\Delta \mu}$.	Partial Dispersion.			Specific Gravity
				A′ to D.	D to F.	F to G′.	
CHANCE'S							
Hard crown	1·5179	·00860	60·2	·00553 ·643	·00605 ·703	·00487 ·566	2·49
Soft crown	1·5151	·00910	56·6	·00577 ·634	·00642 ·705	·00521 ·572	2·55
Titanic crown	1·5432	·01021	53·2	*·00491 ·400	·00722 ·707	·00634 ·622	2·55
Light flint	1·5738	·01385	41·4	00·853 ·615	·00987 ·713	·00831 ·600	3·22
Dense flint	1·6202	·01709	36·2	*·00670 ·399	·01220 ·714	·01122 ·656	3·65
Extra dense flint	1·6489	·01919	33·8	·01152 ·600	·01372 ·714	·01180 ·615	3·87
Double dense flint	1·7174	·02434	29·5	·01439 ·591	·01749 ·718	·01521 ·625	4·49
JENA							
Silicate crown of high refractive power	1·5258	·00872	60·2	·00560 ·642	·00614 ·704	·00494 ·566	2·53
Light borate crown	1·5047	·00840	60·0	·00560 ·667	·00587 ·700	·00466 ·555	2·24†
Silicate glass	1·5368	·01049	51·2	·00659 ·628	·00743 ·708	·00610 ·582	2·76
Borate flint	1·5736	·01129	50·8	·00728 ·645	·00795 ·704	·00644 ·571	2·82†
Medium phosphate crown	1·5590	·00835	66 9	·00546 ·654	·00587 ·702	·00466 ·557	3·07
Borate flint	1·5503	·00996	55·2	·00654 ·656	·00669 ·702	·00561 ·563	2·56
Dense barium phosphate crown	1·5760	·00884	65·2	·00570 ·644	·00622 ·703	·00500 ·565	3·35†
Calcium silicate crown	1·5179	·00860	60·2	·00553 ·643	·00605 ·703	·00487 ·566	2·49
Boro-silicate flint	1·5303	·01114	49·4	·00710 ·637	·00786 ·706	·00644 ·578	2·81

* These intervals are taken from B to D, D to F, and F to G.

† These glasses are very soft or unstable when exposed to the air, and should be protected in use.

i and *i*′, formed by the rays, R O F, are equal at incidence and emergence in this case, but the same relation evidently does not exist, for the ray R′ O V, in which the angles, *i* and *i*′, are very unequal, and therefore this ray cannot be achromatic at the same time.

Forms of lenses than that most nearly approximate to the conditions throughout of equal incidences and refractions at emergence, will conform to the best conditions for actinism as well as aplanatism, as we shall see presently.

We have found, then, from first principles alone, that the main condition for actinism is only one of focal length to be ascribed to the various lenses of the system, and for the best results the powers of these components must be rigidly maintained, whatever may be the ultimate form or selection of curvatures adopted to best suit particular applications.

II.—THE BEST SELECTION OF CURVES ASCRIBED TO THE MATERIAL.

In photographic lenses the curves ascribed to the lenses are spherical, and this form of curve gives rise to what is known as spherical aberration or error, and its effects in single (uncombined or uncorrected) lenses are (*a*) indistinctness of the image formed for the axial pencil, (*b*) curvature of field, (*c*) astigmatism, (*d*) distortion. A perfect photographic lens would be corrected for all these errors; the corrections are approximated by combinations of lenses, and we will proceed to examine the conditions best suited to accomplish each.

(*a*) We have seen that no single lens can be made free from chromatic aberration, nor can it be free from spherical aberration. For a given material of definite refractive index the transversal and longitudinal measurements of the aberration vary with the shape of the lens, and, again, the spherical aberration varies with the aperture and the index of refraction of the glass.

For convenience in arriving at accurate results, it is best to separate the smaller errors, shown by a second approximation, from the main or first approximation. Thus, to arrive at a first approximation, we have the well-known formula connecting the radii and refractive index of the material with the focal length:—

$$\frac{1}{f} = (\mu - 1)\left\{\frac{1}{r} + \frac{1}{s}\right\}$$

Then, in a second approximation, we have two additional corrections to consider, viz., the thickness of the lens and the measure of aberration, *t* being the thickness, and *y* the semi-aperture—

$$\frac{1}{f} = (\mu - 1)\left\{\frac{1}{r} + \frac{1}{s}\right\} - \frac{(\mu - 1)^2}{\mu}\,\frac{ft^2}{r^2} - \frac{\mu - 1}{2\,\mu^2}$$

$$\left\{\frac{1}{r^3} + \left(\frac{1}{s} + \frac{\mu + 1}{f}\right)\left(\frac{1}{s} + \frac{1}{f}\right)^2\right\} f^3\,\frac{y^2}{f} \ldots (2)$$

the negative signs indicating a diminution of the first approximate value.

The third term cannot be made nothing for any known material, but it is interesting to make this quantity a minimum with definite media of different refractive indices. In most text-books this is done for glass of the nominal refractive index $\mu = 1{\cdot}5$. Taking a definite focal length and aperture for parallel rays, we have to decide what values to ascribe to the radii *r* and *s*, to satisfy the condition.

Calling the reciprocals of the focal length and the radii F, R, and S, we have

$$R = -S + \frac{F}{\mu - 1},$$

and using this notation,

$$R^3 + [S + (\mu + 1)\,F]\,(S + F)^2 = \text{minimum}.$$

Differentiating, and substituting

$$-1 \text{ for } \frac{d\,R}{d\,S},$$

$$-3R^3 + 2[S + (\mu + 1)\,F]\,(S + F) + (S + F)^2 = 0$$

and substituting again

$$-S + \frac{F}{\mu - 1} \text{ for } R$$

we get

$$\left\{\frac{6}{\mu - 1} + 2\mu + 6\right\} S = \left\{\frac{3}{(\mu - 1)^2} - 2\mu - 3\right\} F.$$

here if $\mu = 1{\cdot}5$, $21S = 6F$, and hence

$$\frac{1}{s} = \frac{2}{7f}, \quad \frac{1}{r} = \frac{12}{7f}, \text{ or } r : s :: 1 : 6;$$

commonly known as the crossed lens.

Supposing the refractive index were higher, say 1·6, here $r : s :: 1 : 15$ to satisfy the above condition, and the lens assumes a shape nearer the convexo-plane lens.

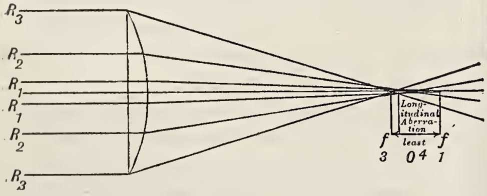
For a given glass of known index of refraction, and assuming various ratios between the radii of curvatures, we can from equation (2) find at once expressions that show the amount of aberration in any chosen form. In speaking of lenses it is essential that the term used to describe the lens should define the surface on which the pencil of rays is incident, thus a plano-convex lens means that the rays are incident upon the plane side, and a convexo-plane lens that the rays are incident upon the convex side.

Now, taking the usual Table thus calculated for ordinary forms of single lenses (for parallel rays), in which the refractive index $\mu = 1{\cdot}5$, and including the correction for thickness, let us see what we can learn here.

	Distance of least circle of aberration from approximate focus.		Diameter of least circle of aberration.
Plano-convex lens ..	$\frac{27}{8}\frac{y^2}{f}$	....	$\frac{9}{4}\frac{y^3}{f^2}$
Equi-convex lens ..	$\frac{1}{6}t + \frac{5}{4}\frac{y^2}{f}$	....	$\frac{5}{6}\frac{y^3}{f^2}$
Convexo-plane lens .	$\frac{2}{3}t + \frac{7}{8}\frac{y^2}{f}$	....	$\frac{7}{12}\frac{y^3}{f^2}$
Crossed lens......	$\frac{24}{29}t + \frac{45}{56}\frac{y^2}{f}$	....	$\frac{15}{28}\frac{y^3}{f^2}$

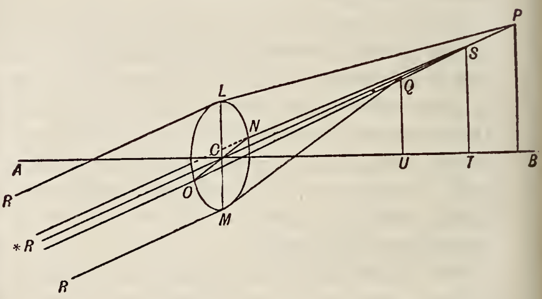
We see that in each change of form the position and diameter of the least circle of aberration differs; the longitudinal aberration increases or diminishes as the square of the diameter of the aperture and inversely as the focal length, and the least circle of aberration is proportional to the cube of the aperture and inversely as the square of the focal length. Thus for two lenses similar in radii and glass, but one having twice the diameter of the other, the larger lens will have a longitudinal aberration four times as great, and the least circle of aberration will be eight times as great; and again of two lenses of the same aperture, but one double the focal length of the other, the longitudinal aberration will here be the half (or inversely as the focus) and the diameter of the least circle of aberration the quarter (or inversely as the square of the focus).

FIG. 3.



Thus to diminish aberration in a single lens the only remedy is to stop it down, but this can never entirely cure it. Now with a given material we have for a definite focal length the best form to ascribe to the lens to reduce the aberration of the central or axial pencil to a minimum, and we can further improve this by stopping the lens down. For photographic purposes we have now to consider the best form to ascribe to this lens to fulfil the other conditions that are also required for the formation of a distinct image. These investigations with a single lens are fully dealt with in Sir G. Airy's paper "On the Spherical Aberration of Lenses," and for a fuller investigation I must refer you to it. The steps necessary are (1) to find proportion of the tangents of the angles made by the axis of a pencil with the axis of a lens before and after refraction; (2) the distance from the lens of the plane perpendicular to the axis of the lens at which the convergence of the rays, in a perpendicular or vertical plane, takes place; and (3) the distance from the lens of the plane perpendicular to the axis, and in a horizontal plane at which the convergence of the rays takes place. The difference of the positions of these planes of the primary and secondary foci gives rise to the effect of astigmatism. A geometrical illustration will probably explain the matter more clearly, and I think you will find these preliminary investigations of considerable use in the more complicated ones of combinations and systems of lenses to be dealt with later.

FIG. 4.



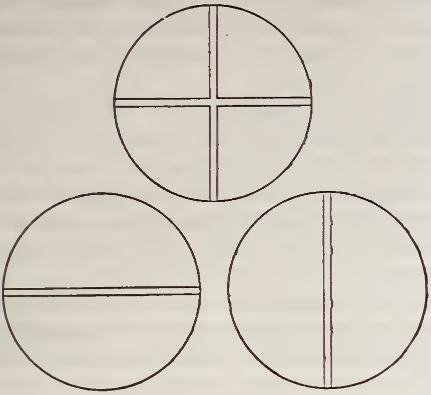
The effect of astigmatism in lenses appears to be little understood, so I offer you the following practical interpretation of the theoretical deductions above referred to in connection with Sir George Airy's admirable analytical treatise.

It has been frequently asked what coma and astigmatism are. Coma is astigmatism, the vertical focal plane being corrected pretty accurately throughout the plane of the image, but the horizontal focal points being situated, off the axis, in very widely-different planes.

Take the plano-convex lens and the convexo-plane lens with a plate having a narrow slit cut across it in conjunction with the lens.

Now, in either case the vertical plane off the axis will have a certain curvature of the field, but the image for the oblique pencils will be distinct (in a sense). Now, if the plate be

FIG. 5.



turned so as to take the horizontal focal plane at positions where the image was distinct for the vertical focal plane, it is no longer so for the horizontal plane, but a very strong coma is visible; with the plano-convex lens coma-*out*, and with the convexo-plane coma-*in*. Now, the vertical plane has less curvature of field than the horizontal, so that by cutting off the horizontal and using the vertical, coma ceases.

I may mention here that if astigmatism in a single combination or any system of lenses were entirely cured, there should be the same focus for both planes.

In testing lenses for astigmatism this is a very powerful method of finding the amount. The effects of observing a point of light are very interesting, as is also the use, in double combinations, of an astigmatic stop.

From the general formula deduced from the three investigations above, applied to a case to find the distance of the diaphragm and the radii of the surfaces most favourable to the formation of a distinct image, it is found that it is not possible to form an image perfectly distinct on a plane, although a distinct image can be formed on a curved spherical surface, the curvature of which is dependent on the refractive index and the focal length; in fact, its radius is μ F.

In these two cases (shown on black board), the diaphragm in one case is situated behind the lens at a distance

$$\frac{\mu - 1}{\mu^2 + \mu + 1} f.$$

$$\text{Radius R} = \frac{\mu - 1}{\mu^2} f. \qquad \text{Radius S} = -\frac{1}{\mu - 1} f.$$

The other case is the plano-convex lens, where the distance of the diaphragm

$$= \frac{\mu - 1}{\mu} f$$

$$r = \infty$$

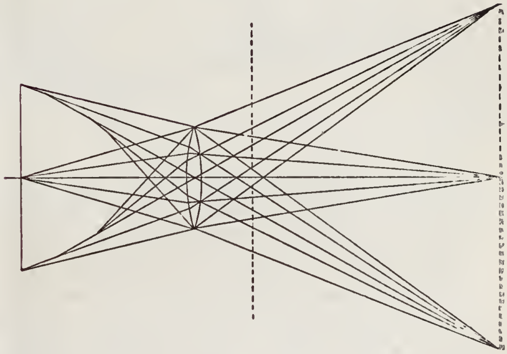
$$s = (\mu - 1) f.$$

And as the curvature of field is dependent on μ, the higher the refractive index, the less curved will the field become.

The effect of the diaphragm has a most important bearing on astigmatism, curvature of field, and distortion. In connection with astigmatism, the use of the diaphragm is the only means, in a single lens or system of lenses, of diminishing it if it should exist. On curvature of field and distortion it acts in exactly opposite directions (in single lenses or single cemented combinations of more than one lens).

Take the case of the plano-convex lens above with a small diaphragm in contact. The curvature of field here will be very considerable, but the distortion practically *nil*. Now the further the diaphragm is removed from the lens the greater becomes the distortion, but the less the curvature. The following illustration will explain the effect of the diaphragm on curvature.

FIG. 6.



It will be seen that by limiting the aperture the image forming rays for each small pencil are closer together and are not interfered with by those that have shorter foci, and would meet the lens at far greater refracting angles if the full aperture were employed. The further the diaphragm is removed the flatter does the field become, but more distortion is introduced.

(d.) Distortion. The usual and simplest manner to describe this is to find the appearance after refraction of a square grating when

the diaphragm, supposed small, is placed in front of the lens, and the field "flat" or cured of curvature. It will be seen from the accompanying figure, where the refracting angle is greatest, viz., the furthest away from the axis, the pencils are more refracted towards the axis than they are as they approach the axis, the axis itself suffering no displacement. The single rays of course may be taken as the axes of pencils. You will thus see that the pencils representing the lines become convergent towards the axis. This distortion is known as "barrel-shape" distortion. The opposite distortion, called pin-cushion, occurs if the diaphragm be placed behind the lens, as in the following figure, where there will be seen a divergence from the axis, becoming more and more marked as the refracting angles become greater towards the edge of the lens. The "barrel-shape" distortion is generally considered the less disagreeable of the two, and hence the diaphragm is usually placed in front of the single lenses. The following Figure illustrates the cure of distortion by opposing the errors above referred to in the separate lenses by their combination, but it must be understood that although this is perhaps the simplest form of making a non-distorting or rectilinear lens, it is not the only way in which the cureof distortion is attained, but is sufficient to explain by its simplicity the general principle involved.

FIG. 7.

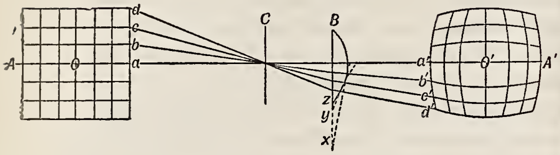


FIG. 8.

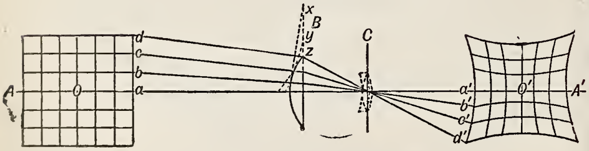
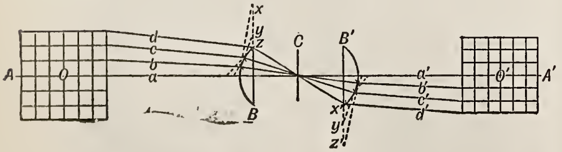


FIG. 9.



Being now familiar with the effects of spherical aberration as produced by single lenses, and the general principles adopted to eliminate these errors, we will proceed to investigate how combinations of lenses may still further and better tend to annihilate the errors of form.

The various applications of lenses to different purposes will indicate the most appropriate directions in which to work to accomplish this. For very rapid lenses, such as are used in portraiture, it is necessary to pay strict attention to the aplanatism of the central pencil, and choosing such forms as are best suited to eliminate curvature of field, astigmatism, and distortion, but these latter are made subservient, in the main, to those of rapidity. When, however, aperture may be sacrificed, we are enabled to lay greater stress on the three latter considerations, but in every case the skill of the optician consists in the best compromise among the effects of aberration.

We have seen that a single glass lens can neither be achromatic nor aplanatic for parallel rays, but we have found that a single lens can be made achromatic by combining it with another lens of different dispersive power; the condition for axial achromatism being merely one of the correct relation between the focal length of the lenses or their powers. Let us now examine the condition for aplanatism by combination with another lens.

In the first approximation combining two lenses we have—

$$\frac{1}{v_1} = \frac{1}{f_1} - \frac{1}{u}$$

$$\frac{1}{v_2} = \frac{1}{f_2} + \frac{1}{v_1}$$

$$= \frac{1}{f_1} + \frac{1}{f_2} - \frac{1}{u}$$

so that if the lenses are in contact, the effect is the same as one lens equal to the *algebraical sum* of the *powers* of each; if the second lens was negative, for example, we should get—

$$\frac{1}{v_2} = \frac{1}{f_1} - \frac{1}{f_2} - \frac{1}{u};$$

and with any number of lenses—

$$\frac{1}{v_n} = \frac{1}{f_1} + \frac{1}{f_2} + \ldots\ldots + \frac{1}{fu} - \frac{1}{u}.$$

We have found a second approximation for a single lens showing the aberration, and for our purposes here this may be put under a more convenient form.

$$\text{Since } \frac{1}{u}+\frac{1}{v}=\frac{1}{f}, \qquad \text{and } \frac{1}{r}+\frac{1}{s}=\frac{1}{\mu-1}\,\frac{1}{f};$$

$$\text{Let } \frac{1}{u}=\frac{1}{2f}(1+a), \qquad \frac{1}{r}=\frac{1}{2(\mu-1)f}(1+x),$$

$$\frac{1}{v}=\frac{1}{2f}(1-a), \qquad \frac{1}{s}=\frac{1}{2(\mu-1)f}(1-x).$$

If we then find the values of

$$\left\{\frac{1}{r}+\frac{1}{u}\right\}^2 \text{ and } \left\{\frac{1}{s}+\frac{1}{v}\right\}^2$$

we obtain the second approximation in a more convenient form after the necessary reductions, viz. :—

We have at the first lens,

$$\frac{1}{v_1}=\frac{1}{f}-\frac{1}{u}+\frac{1}{\mu(\mu-1)}\left\{\frac{\mu+2}{\mu-1}x^2+4(\mu+1)ax\right.$$

$$\left.+(3\mu+2)(\mu-1)a^2+\frac{\mu^3}{\mu-1}\right\}\frac{y^2}{8f^3}.$$

This may be written

$$\frac{1}{v^1}=\frac{1}{f_1}-\frac{1}{u}+\omega_1 y^2,$$

and on passing to the second lens

$$\frac{1}{v_2}=\frac{1}{f}-\frac{1}{u}+\omega_2 y^2$$

$$=\frac{1}{f_1}+\frac{1}{f_2}-\frac{1}{u}+(\omega_1+\omega_2)y^2.$$

and in general—

$$\frac{1}{v_2}=\frac{1}{f_1}+\frac{1}{f_2}+\frac{1}{f_3}+\ldots\frac{1}{f_n}-\frac{1}{u}+$$

$$(\omega_1+\omega_2+\ldots\omega_n)y^2.$$

The object then for aplanatism is to make

$$\Xi\,\omega=0.$$

Now this can always be done by assuming a definite ratio between the radii of one lens and finding the ratio between the radii of the second that shall destroy the first aberration.

Now if we call r_1 s_1 the radii of the first lens, and r_2 s_2 the radii of the second lens, and take a form of aplanatic combination, such as the rapid rechlinear, in which both front and back combinations are identical with cemented and identical contracts.

Here s_1 and r_2 are identical except in sign, and if the glasses chosen are suited, there is only one form for the best correction for spherical aberration. The ratio of the powers is a constant, and therefore by a proper substitution in the above equations, this construction becomes a simple matter. The question evolves itself into a simple quadratic, one root of which is usually imaginary. Should both be imaginary, the glasses are unsuited to the purpose, and a symmetrical system cannot obtain.

The front combination alone with its convexity towards the object for the oblique pencils has a powerful coma-*in*, and the back combination alone, with its concavity outward, a powerful coma-*out*. The two in the combination have the effect of counterbalancing one another, more or less according to the selection of suitable material. The residuum effect of aberration for the oblique pencils being visible as astigmatism or curvature of field, but distortion is destroyed. A proper selection of the new glasses certainly enables improvements in both these respects with larger apertures than was formerly possible.

For the elucidation of the possiblities of producing combinations of large aperture suited to portrait work, at a period, too, when rapidity was of the utmost importance, we owe a great debt of gratitude to the prince of mathematical opticians, Professor Petzval. His portrait combination, known to you all, was a triumph, and the result of pure analytical investigation. He proved to working opticians the possibilities of vast improvements in the instruments then made, and also confirmed them in many of their geometrical and practical deductions.

I have made a drawing (which is seen on the screen), tracing the course of the rays through a Petzval combination for the oblique as well as the central pencil, and it serves to show how perfectly the mathematical elegance—perhaps I should say labour—brought to bear on this subject corresponds with the general principles then known and worked upon for the best relation to exist between the incidence and emergence of the various pencils to form a distinct image.

I think I may be allowed to mention here, with pardonable pride, my late father's improvements in lenses generally since that period, and particularly with respect to his portrait combination. It was a great advance on that of Petzval, not only for greater covering power, but for strict mathematical capabilities. You are well aware that a lens that is free from spherical aberration for parallel rays is not so for nearer objects, but becomes what is called over-corrected for spherical aberration. Now, in addition to better optical perfection, the form of the back combination, by a mechanical contrivance, of separating the back flint from the crown, will correct or counterbalance the over-correction for nearer objects if necessary, or may, on the other hand, be so far removed as to introduce, according to taste, a considerable amount of positive spherical aberration, that was first asked for by the late Mr. T. R. Williams, to soften the biting sharpness of lenses when required to produce more artistic results.

In slower lenses, where rapidity is sacrificed, a judicious selection of the powers of the elements in the combination or combinations, and arranging their curvature so that, as in the case of achromatism, the pencils at incidence and emergence are similarly treated for every part of the lens, so do we arrive at better perfection of the image, until the maintenance is so perfect that it becomes a parallel with an imaginary pinhole (without diffraction), the aperture or intensity being as great as possible consistent with this perfection.

To conclude, as photography for utilitarian purposes in the sciences and commerce require our lenses to attain the highest mathematical precision, no less does art—and photography is rapidly gaining ground as an art—require the optician to handle the subject in an equally intelligent manner, to give to those instruments wider capabilities.

DISCUSSION.

Mr. CONRAD BECK said they were all very much indebted to Mr. Dallmeyer, but he did not feel that he had any remarks to make without entering on a discussion of technical points which would be quite out of place. He thought, however, it was a slip to say that, in correcting for spherical aberration and achromatism, there was only one form with two kinds of glass, and that the second root of the quadratic was generally imaginary. His impression was that whenever there was one form there was always another; but so far as opticians were concerned, it generally was imaginary, because the lens would have practically no aperture.

Mr. HURRY having referred to the immense progress which had been made in photography since the first attempts by Daguerre,

Mr. TAYLOR (Leicester) said the value of this paper lay in the information it gave the members, which would enable them to follow intelligently the methods used by opticians in their work. Practical men were deeply interested in it, but he did not think they could discuss it in such a way as to be interesting to the meeting.

Mr. DEBENHAM said he was very glad to hear the high tribute paid to Professor Petzval, but for whose efforts photography would not have made much advance, on account of the slowness of any other combination. Petzval and Steinheil were the two great inventors in this matter, and the combination introduced by the latter had been adopted by every optician, and within the last twenty years more lenses had been manufactured on that system than on any other. He did not think Petzval's work had ever been improved, which was very remarkable, considering the length of time it had been before the world. The variation introduced by the late Mr. Dallmeyer had, perhaps, certain advantages, but balancing one thing against another, he did not think his system was, on the whole, superior.

Mr. TRAILL TAYLOR, with a view of directing the discussion into a more practical channel, asked if Mr. Dallmeyer could state how the focal length in a compound lens was to be measured, according to the theory of the nodal points introduced by Gauss. Taking the case of a rapid rectilinear, from what point in the combination should the focus for the distant rays be measured? He thought theory and practice did not quite agree on this point. It was well known that, in the case of a single combination, the nodal point was practically on the centre of the convex surface in a plano-convex lens, and in a meniscus a little beyond it. But in the case of a combination Mr. Cary Lea gave, on the Gauss theory, a point between the lenses a little nearer the back lens than the mechanical centre. But you might assume a combination of two lenses, each of them twenty inches in focus, and separated by such a distance as to bring the posterior lens close up to the plane of representation, the focus of that combination would evidently be measurable from a point very near the front lens; and if so, what became of the theory of Cary Lea, Secretan, and many others? Many complaints were made about the sweating of glass, and he had a very good example of it in a lens which, even when wrapped in paper, would become quite misty in a very short time. Were there any means by which that could be obviated? Some had recommended boiling the lens as a means of removing the sweating principle from the surface.

Mr. BECK said the difference between theory and practice with regard to the Gauss points, arose chiefly from not recognising that the focus on the Gauss system was not measured from one point, but from two. Those two points became one in a very thin lens, and it was very easy to teach students that the focus should be measured from the centre or point in the lens, and to assume that all lenses were thin. For this reason, most of the text-books assumed that the focus was measured from what they called the optical centre, whereas it should be measured from the position in a compound lens, where a thin lens would give the same optical effect. The Gauss points were planes, the principal planes, and in a rapid rectilinear lens those would, each of them, be a little bit on either side of the centre as a rule, if they were perfectly symmetrical. Therefore the focus should be measured from a point slightly nearer the back lens than the centre of the combination. In every compound lens there were two planes, and in a single landscape lens of the kind generally in use the focus was measured from two planes, both of which as a rule were outside the lens, and the position of those planes could be varied considerably, according to the way in which the lens was made. With regard to the new glasses from Jena, he might mention some of the difficulties that occurred in using them. Their great feature was that certain of them had very high refraction to very low dispersion, and, therefore, a pair of cemented lenses could be obtained which would more nearly approach to a concentric lens, or would more nearly refract the oblique pencil in the same manner as the central ones. He believed a patent had been taken out for such a lens, but whether it would hold good was another question, because these glasses could only be made achromatic by using them in the patented manner. The great difficulty at present was that, with the glasses as now made, the lenses had to be made so nearly of the same focus that there was great difficulty in making them commercially, and the glasses most useful for this particular purpose would not stand the action of the air. At the same time, an enormous field had been opened up by the introduction of these glasses, and the calculations were extremely laborious. There were as many as 1,900 different kinds, all of which had to be thoroughly worked out before it could be said that no further improvements could be made. Slight improvements had been made in photographic lenses since their introduction, but whether the principle of curing astigmatism could be carried to as great an extent as some were sanguine enough to hope, would depend very largely on whether the manufacturers could carry their experiments a little further, and produce glass rather more extreme still.

Mr. LASCELLES SCOTT said when the first accounts reached this country of the researches of Abbe of Jena, a paragraph went the round of the scientific papers to the effect that some wonderful photographic lenses were coming which would be chemically refractive, that although the surfaces would be nearly flat, yet from a difference in their density and refractive power, they would have the power of converging or diverging the rays of light. Nothing had been heard of this lately, and it would be interesting to many to know if there was any hope in that direction. He would also ask if any experiments had been made with tinted glasses with a view to greater rapidity in cutting off the red and some of the yellow rays. He had found that, with a dilute solution of ammonio-sulphate of copper placed in front of a lens, there was a saving of from 5 up to 20 or 25 per cent. in the exposure required, compared with light transmitted through pure water.

Mr. DALLMEYER, in reply, said he might perhaps have been not quite accurate in what he said about the imaginary root, but he thought Mr. Beck understood what he meant. With regard to particular glasses, it would be better, certainly, if they could get a greater difference between the dispersions, with the refractive indices as they were. Most of the glass now showed about the same dispersive power, and had convenient refractive indices for the formation of positive images, but if the dispersive powers varied more it would be an advantage. He thought Mr. Traill Taylor knew all about the Gauss points, because he had published three admirable methods of finding the point referred to in a double combination. One was by taking the angular measurements to get at the optical centre; another, of Schroeder's, was to focus the object for equal size of object and image, and then to wheel it in to the parallel rays and take the measurement; and a third which he had himself suggested. There was a great deal of sweating some years ago, until Dr. Hopkinson made his experiments. Of course if glass had this fault very badly, opticians would not use it, as Mr. Beck said they could not use some of these glasses from Jena from which so much was expected. The only way was to sandwich them in between other glasses which would stand the effects of the atmosphere. He did not want to refer to patent lenses, but Mr. Beck had stated what was exactly the case, if you wanted a positive image, and such glasses were used, there could be no good claim to make them in a concave form. He did not want to discuss the forms of lenses, but it was a necessity with certain glasses that there should be an exterior concave element. The addition of tinted glass was a very old way of using lenses, but he thought it had been abandoned. The idea was to use a blue tint to get the actinic ray; but though you used the blue, the green and other portions of the spectrum, which also acted on the chemical salts, were not used. A powerful portion of the spectrum was used, but not the whole of it, as when you used white light. It was better to use the whole than only a part, until you came to the yellow or chromatic glass, in which a great deal was done for bringing out the colours that were non-actinic. He always should and did consider Petzval the prince of mathematical opticians, but he was also proud of his father's improvements, which had been appreciated by the optical world generally.

The CHAIRMAN said he had always taken it that the way to measure the focal length of double lenses was to take a pinhole, and not a single lens, as a criterion. If you took with a pinhole a picture the same size as the double combination would give, the distance of the pinhole from the screen was the focal length of the combination, and you had to measure back from the screen to between the lenses to find the point. It varied according as you had a near object or a distant one. He had had some experience of the Jena glass, and it was the worst of all for sweating; it would not stand the atmosphere at all. Of course the way to obviate that would be to sandwich it, and he had had excellent proof of the efficiency of that method. Some time ago he wished for a lens made for a special purpose, in which rock-salt should form a part, and he got a friend to make him two concave lenses, between which was placed one of rock-salt. Everyone knew how deliquescent that was, but it was as perfect now as it was five years ago. The focal length of lenses differed according to the part of the picture you measured from; and on this point there was fine scope for argument. You might say the focus should be taken from the centre of the lens, or from the side of the picture; it did not always follow that you focussed from the centre; you might focus half way between the centre and the side. He was rather surprised to hear that the use of a solution of ammonio-sulphate of copper enabled the exposure to be decreased, because a great many chemically active rays would be cut off by that solution. He could understand that in a case where you were using iodide of silver such a substance might possibly lessen the exposure, because the red and yellow rays had a reversing action where the non-oxidising action took place as far as the line G and the ultra violet. In fact, some experiments of his own seemed to show that a difference of about 1 or ½ per cent. in iodide of silver, when all but the active rays from G to the ultra violet were cut off. But he should not have expected that it would decrease the exposure by 25 per cent., and should not advise it to be practised except experimentally. He concluded by proposing a vote of thanks to Mr. Dallmeyer for his extremely able paper, which was carried unanimously.

Miscellaneous.

PARIS EXHIBITION.

The Report of the Executive Council of the British Section has just been issued. The total revenue received by the Executive Council amounted to £29,422, of which £20,601 was received for space, besides £200 under the same head for the Indian Pavilion. £1,618 was obtained by the sale of concessions for catalogues, the Ceylon tea bar, &c. The donations amounted to £1,890, of which £1,581 was for the Fine Art Section. The principal items of expenditure were decorations, £5,033; payments for flooring, &c., to the French authorities, £2,257; salaries and wages, £8,270. The Indian Pavilion cost £3,723, and the charges in connection with the Fine Art Section were £3,864. The excess of receipts over expenditure amounted to £436. Of this, £105 was voted to the French Hospital in London, and the balance, £331, is available to meet a few charges which still remain to be paid. The accounts have been audited by Messrs. Turquand and Co. The Report also gives an account of the proceedings of the committee since the commencement, most of the information contained in which has, of course, already been published in various forms. In appendixes to the Report are given lists of the Council, committees, jurors, &c., a synopsis of the classification, and a list of the awards to English exhibitors.

SERICULTURE IN TRANSCAUCASIA.

The rearing of the silkworm is carried on in 1,650 communes in Transcaucasia, and the number of persons engaged in the industry is stated by the *Journal de la Chambre de Commerce de Constantinople* at 400,000. The production of raw silk amounts to about 20,000 poods per annum (pood = 36 pounds avoirdupois). The mulberry tree grows luxuriantly throughout the whole extent of the country, and there are six descriptions of the white, black, and wild mulberry cultivated. Some of these varieties are much appreciated for the delicacy of their fruit. The leaf of the white wild mulberry is usually used for the food of the worms. The old Caucasian race of silkworms has almost died out, and at the present time there are only a very few remaining. The descriptions now reared are the Thurbat Khorassan and the green worms of Turkey and Europe. The amount of seed incubated annually is estimated at 800,000 ounces, yielding from 10 to 14 kilogrammes of cocoons to the ounce. Since the year 1884 considerable quantities of European seed has been imported. The breeding is carried on in the houses of the persons engaged in this business, or in buildings specially constructed for the purpose. The worms are placed upon screens, but more frequently they are simply placed upon the ground. In the rearing of the worms sufficient care is not taken, the beds are never changed, the worms themselves have not sufficient space and are ill fed. The consequence of the overstocking and ill-feeding is that the worms degenerate and become a prey to destructive diseases. The most important of these are the *pébrine* and the *muscadine*, the losses sustained from the former are estimated at about 60 per cent. The cocoons are sold by the breeders either fresh or dried naturally in the sun, and the prices realised are from 10 to 11 roubles for each 16 kilogrammes of fresh green Japanese cocoons, and from 14 to 25 roubles for the yellow European. Each breeder keeps a certain quantity of cocoons for spinning. The silk is spun with very primitive tools, and the silk itself is of a coarse description, employed in the manufacture of sewing silk cords and native tissues, such as *djedjimes*, *darajas*, &c. The weaving may be divided into two categories—that carried on in the various households, and the industry as engaged in workshops and factories devoted to the purpose. The former is much engaged in the Tartar provinces and the western provinces of Transcaucasia. The work is done by women, who weave on very simple looms two kinds of stuffs; several descriptions of white or coloured taffetas, which are called *daraja*, *merdiné*, and *kanaous*, and a tissue peculiar to Persia and Transcaucasia called *djedjime*. Industrial weaving is carried on at Seemaclia and in the neighbourhood, also at Shoussa, Elisabetpoli, and Gadronte. The factories are not large, and they contain from one to ten looms, roughly constructed after an Asiatic model. The weavers, who are mostly men, manufacture *Kanaous* shawls of different qualities and dimensions and various Asiatic stuffs. The manufacture of silk for sewing and embroidery is carried on to a very considerable extent, but the production is not very great. The silk is dyed with vegetable colours and aniline. Each family prepares for its own use various little articles of silk such as strings, stockings, foulards, veils, &c., which are as a rule manufactured with considerable skill. The manufacture of open work goods such as shawls, gloves, laces, &c., is chiefly carried on in Hakhétie and in the western portion of the country. The value of all these articles is estimated at £280,000, and the total production of silk and silk goods in the country is stated to be worth £840,000. In conclusion the *Journal de la Chambre de Commerce de Constantinople* says that sericulture is of very considerable importance in Transcaucasia, and occupies the third place in the various branches of the agricultural industry of the country.

Correspondence.

COAL IN SOUTH EAST ENGLAND.

At the close of Mr. Whitaker's paper on Wednesday last, Dr. Geikie briefly alluded to an effort about to be made to further elucidate this question; but as he did not give any particulars relative to the same, perhaps you will allow me, as organiser of the movement, to say a word or two on the subject.

A large and influential committee of geologists and others is being formed to "institute a complete scientific investigation as to the occurrence and distribution of coal in the South East of England," by borings or other suitable means.

Before this is done, however, it will be necessary to raise a fund for the purpose, and it is proposed to do this by an appeal through the Press or other agencies which the committee may deem desirable.

Within the next few years many thousands of pounds will no doubt be spent in abortive efforts to reach the precious mineral in Kent, Surrey, and Sussex; and if I may be allowed to give a word of advice to intending explorers, I would say, "Wait until this committee has published the result of its investigations before you spend your money," and meantime subscribe to the fund as the surest means of securing the best information on the subject.

Furthermore, as the committee approach the question in a public spirit, without the least hope of fee or reward of any kind, I trust those whose interests lie in the direction of coal discoveries will respond freely to the appeal, and I beg you will help the matter by giving publicity to this letter.

JAMES T. DAY, F.G.S.

12, Albert-square, Stepney, E.
April 28, 1890.

Notes on Books.

AGENDA DU CHIMISTE. By G. Salet, Ch. Girard, and A. Pabst. Paris: Hachette. 1890.

This is the fourteenth issue of this chemical notebook, originally prepared from the manuscript notes of Professor Wurtz, and issued annually since 1877. The first portion of the work consists of mathematical tables, lists of weights and measures, specific densities, &c. The second part relates to pure chemistry, and includes a list of elements, with their characteristics; also a list of a number of organic and inorganic compounds, with their principal characteristics. The third part relates to applied chemistry, and describes methods of analysis suitable for various industries, such as glass, pottery, sugar, alcohol, wine, paper, dyes, &c. The little book contains a great deal of information of a character useful to those engaged in practical chemical work.

NATIONAL HEALTH. By Benjamin Ward Richardson, M.D., F.R.S. London: Longmans, Green, & Co.

This is an abridged and popular edition of the collection of Sir Edwin Chadwick's works which was published by Dr. Richardson under the title of "The Health of Nations." It is preceded by a biographical sketch of Sir Edwin Chadwick.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

MAY 7.—DR. PERCY F. FRANKLAND, "The Aim and Scope of Higher Technical Teaching."

MAY 14.—Dr. J. A. FLEMING, "Prof. Elihu Thomson's Electro-Magnetic Induction Experiments."

INDIAN SECTION.

Thursday afternoons, at Five o'clock:—

MAY 8.—DEMETRIUS BOULGER, "The Western Frontier of China." Major-General Sir OWEN T. BURNE, K.C.S.I., C.I.E., will preside.

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock:—

MAY 13.—Prof. W. C. ROBERTS-AUSTEN, F.R.S., "The Use of Alloys in Art Metal-work."

CANTOR LECTURES.

Monday evenings, at Eight o'clock:—

RICHARD BANNISTER, "Sugar, Tea, Coffee, and Cocoa, their Origin, Preparation, and Uses." Four Lectures.

LECTURE II.—MAY 5.—*Sugar* used in brewing, distilling, and jam-making. *Coffee*—History—Introduction into Europe—Varieties—Composition of coffee when raw and roasted—French coffee—Coffee substitutes and their detection.

ADDITIONAL LECTURES.

Thursday evenings, at Eight o'clock:—

LEWIS F. DAY, "Design applied to Wood-Carving." Three Lectures.

LECTURE II.—MAY 8.—Carpentry, joinery, and the ruder forms of carving connected with them—Effective carving—Gothic and Elizabethan design—Geometric forms—Design in reference to high and low relief—Undercutting—The relation of the carving and its design to the wood—The rendering of natural forms—The treatment of the ground—Pierced work—Handling.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MAY 5...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Richard Bannister, "Sugar, Tea, Coffee, and Cocoa, their Origin, Preparation, and Uses." (Lecture II.)

Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.

Engineers, Westminster Town-hall, S.W., 7½ p.m. Mr. F. H. Cheesewright, "Breakwater Construction."

Chemical Industry (London Section), Burlington-house, W., 8 p.m. 1. Mr. Watson Smith, "The Dunsmere Process." 2. Messrs. Cross and Bevan, "Some Considerations on the Chemistry of Bleaching." 3. Mr. M. T. Greffin, "Moisture in Paper Pulp."

British Architects, 9, Conduit-street, W., 8 p.m. Annual Meeting.

Medical, 11, Chandos-street, W., 8½ p.m. Annual Oration.

Victoria Institute, 1A, Adelphi-terrace, W.C., 8 p.m.

TUESDAY, MAY 6...Royal Institution, Albemarle-street, W., 3 p.m. Mr. L. Fagan, "The Art of Engraving." (Lecture I.) "Line Engraving."

Central Chamber of Agriculture (at the HOUSE OF THE SOCIETY OF ARTS), 11 a.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. Syd. W. Barnaby, "The Screw-Propeller."

Pathological, 20, Hanover-square, W., 8½ p.m.

Biblical Archæology, 9, Conduit-street, W., 8 p.m.

Zoological, 11, Hanover-square, W., 8½ p.m. 1. Prof. F. Jeffrey Bell, "Observations on a particularly Fine Example of the Black Coral of the Mediterranean, lately acquired by the Trustees of the British Museum." 2. Mr. E. N. Buxton, "Notes on the Wild Sheep and Mountain-Antelope of Algeria." 3. Mr. R. Lydekker, "A remarkable Antler from Asia Minor." 4. Mr. F. E. Beddard, "The Minute Structure of the Eye in some Shallow-water and Deep-sea Species of the Isopod Genus *Arcturus*.

WEDNESDAY, MAY 7...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Dr. Percy F. Frankland, "The Aim and Scope of higher Technical Teaching."

Inventors' Institute, 27, Chancery-lane, W.C., 8 p.m. Mr. Henry Middleton, "Submarine and Submergeable Vessels."

Entomological, 11, Chandos-street, W., 7 p.m.

Archæological Association, 32, Sackville-street, W., 4½ p.m. Annual Meeting.

Obstetrical, 20, Hanover-square, W., 8 p.m.

THURSDAY, MAY 8 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m. (Indian Section) Mr. Demetrius Boulger, "The Western Frontier of China." At 8 p.m. (Additional Lectures.) Mr. Lewis Foreman Day, "Design applied to Wood-carving." (Lecture II.)

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Chemical, Burlington-house, W., 8 p.m. Extra Meeting. Exhibition of Apparatus.

Royal Institution, Albemarle-street, W., 3 p.m. Professor Dewar, "Flames and Explosives." (Lecture I.)

Electrical Engineers, 25, Great George-street, S.W., 8 p.m. 1. Discussion on the following paper by Dr. Oliver Lodge, "A Lightning Guard for Telegraph Purposes, and on the Protection of Cables from Lightning." 2. Major P. Cardew, "The Treatment, Regulation, and Control of Electric Light by the Legislature and the Board of Trade."

Mathematical, 22, Albemarle-street, W., 8 p.m.

FRIDAY, MAY 9...United Service Inst., Whitehall-yard, S.W., 3 p.m. Captain R. Holden, "The Enlistment of the Militia for Foreign Service."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Mr. R. Brudenell-Carter, "Colour Vision and Colour-Blindness."

Astronomical, Burlington-house, W., 3 p.m.

Clinical, 20, Hanover-square, W., 8½ p.m.

New Shakspere, University College, W.C., 8 p.m. Paper by the Rev. W. A. Harrison.

SATURDAY, MAY 10...Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Dr. C. Waldstein, "Recent Excavations in Greece." (Lecture I.)

CORRECTION.—The right-hand references to the upper section on p. 546 (Mr. Whitaker's paper on "Coal in the South East of England") should stand as follows:—

Regularity	5. Lower Greensand.
Irregularity	6. Weald Clay. 7. Hastings Beds.
Regularity	8. Jurassic Beds.

Journal of the Society of Arts.

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FRIDAY, MAY 9, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

ADDITIONAL LECTURES.

The first lecture of a course on "Design applied to Wood-Carving," was delivered by Mr. Lewis F. Day, on Thursday evening, 1st inst.

CANTOR LECTURES.

Mr. Richard Bannister delivered the second lecture of the course on "Sugar, Tea, Coffee, and Cocoa, their Origin, Preparation, and Uses," on Monday evening, 5th inst., in which he concluded the subject of Sugar, and dealt with Coffee and Coffee Substitutes.

These lectures will be printed in the *Journal* during the autumn recess.

Proceedings of the Society.

TWENTIETH ORDINARY MEETING.

Wednesday, May 7th, 1890; C. M. Kennedy, C.B., Member of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Gover, Henry, 3, Adelaide-place, E.C.
Greenwell, George Clementson, jun., Poynton, Cheshire.

The following candidates were balloted for and duly elected members of the Society:—

Denison, Samuel, Old Grammar School Foundry, North-street, Leeds.
Kerr, John, 101, Leadenhall-street, E.C.
Leslie, Sir Bradford, K.C.I.E., Tarrangower, Willesden-lane, Brondesbury, N.W.
Pender, Sir John, K.C.M.G., 18, Arlington-street, S.W., and 50, Old Broad-street, E.C.
Stillwell, Lewis B., Westinghouse Electric Company, Pittsburgh, Pa., U.S.A.

The paper read was—

THE AIM AND SCOPE OF HIGHER TECHNICAL EDUCATION.

By Percy F. Frankland, Ph.D., B.Sc., F.C.S.;

Professor of Chemistry in University College, Dundee: St. Andrew's University.

"Technical Education" is a term so often in the mouths and writings of the men of our generation that it would appear at first sight a most gratuitous task either to define its meaning or enter into its aim and scope. On careful inquiry it is, however, readily apparent that the words are intended to signify one thing by some, another thing by others, whilst as used by the great majority they have little or no significance whatever.

Without discussing the several meanings which the words are intended to convey by others, I will simply at the outset say that what I understand by "technical education" for the purposes of this evening's discourse, is all such education as is calculated to specially fit a person for any particular department of productive activity.

The subject of technical education in its elementary branches has been already so fully and ably treated of in this place during the present session by my friends Dr. Gladstone and Professor Silvanus Thompson, that it would be altogether unnecessary to take up your time with any further discussion of those matters. It is, on the other hand, with the scope of and opportunities afforded for the higher education of a technical character that I propose to deal this evening.

Now, just as I understand technical education in general to comprise all such education calculated to specially fit a man for any particular productive vocation in life, so by "higher technical education" I understand all such education as is intended to fit him for the higher departments of productive activity. Speaking generally, it can therefore be taken to include such special instruction as may be advantageously superposed upon the undifferentiated highest class school education of the day. In a more restricted sense then, for practical purposes, this higher technical education is intended for those aspiring to become architects, engineers, technical chemists, manufacturers of any kind, agriculturists or planters, using all these terms in their widest acceptation.

If we inquire into the kind of education which is sought by the aspirants in these several departments of industry, we shall find that in nearly all cases there is the greatest difference of opinion amongst individuals as to what is necessary, and that, with few exceptions, there exist no definite lines upon which the candidates for these careers can prepare and qualify themselves. The candidates for such careers find themselves in a far more difficult and uncertain position than those for the recognised professions of the Church, Law, and Medicine, in which the courses to be adopted for qualification, although admitting of considerable latitude in many respects, are sufficiently clearly marked and well prescribed.

In the older occupations of architecture, engineering, and agriculture, we still find the system of apprenticeship or articled pupilage in existence, either wholly or in part. Now, whatever may be the advantage of this system, and it certainly has some, there can be no doubt, I think, that it is destined to disappear, belonging as it does to a bygone age and to a stationary civilisation of empiricism.

But in such a chaotic and disorganised condition is the whole system of higher technical education in this country, that even in new departments, such as that of industrial chemistry, we actually find a resuscitation of this worn-out fabric of apprenticeship. The cause is obvious enough. The youthful and uninitiated candidate, on looking around at the opportunities of education afforded, failing to find any minutely prescribed course of preparation, such as he would have no difficulty in discovering were he intended for Orders, for the Bar, or for Medicine, attaches himself to the person of some master who, in exchange for a more or less substantial premium, undertakes to initiate him into the mysteries of the craft. Now, whatever may be the advantages of the system of pupilage in the case of architects and engineers, I have no hesitation in saying that in the case of technical chemists it is thoroughly bad, and that it is only after undergoing a most thorough and extended training in some public institution, that a period of pupilage in a private laboratory or office can be recommended.

Let us, in the next place, inquire as to the character of the education which is available in this country for those intending to enter any of those numerous departments of industrial life which are not provided for by any recognised system of pupilage. It has been more especially to meet the wants of these classes that a number of colleges have been established during the last fifty years in various parts of the country. These colleges, as is well known, owe their origin to the munificence of private individuals, and, until recently at any rate, have acted quite independently of each other and of any central educational organisation. Notwithstanding their independent position, they exhibit a certain uniformity in the nature of the instruction which they offer, and this instruction, in most cases, includes not only such subjects as are required for a scientific and technical education, but also a more or less limited number of arts-subjects as well. In thus endeavouring to accomplish too much, these colleges have undoubtedly achieved much less than they might have done had their aims been more modest. Thus, whilst in many cases their scientific departments have been very successful, and their scientific teaching not unfrequently as high in standard and as wide in extent as any that is to be found in the United Kingdom, their departments of arts have never formed more than good preparation grounds for the universities.

As regards the opportunities which these local colleges afford for technical instruction, in the widest acceptation of the word, there can be no doubt that, on the whole, they are extremely good. The provisions made for the teaching of the fundamental sciences of mathematics, physics, and chemistry are generally excellent, whilst the descriptive sciences of zoology, botany, and geology are also, in some cases well provided for; in most cases, also, particular care has been bestowed upon the equipment of a school of engineering; and in individual cases, as at Leeds, Bradford, and Dundee, provision is made for practical teaching in such technical specialities as dyeing, bleaching, weaving, &c.

When I first became attached to one of these institutions myself, and had duly learnt to understand its aims and mode of operation, I conceived it to be my duty to make myself more fully acquainted with the present condition of higher technical teaching in those countries which are the most famed in this respect, viz., Germany and Switzerland. In the autumn of last year I, therefore, visited all the "polytechnical" schools of these countries, and endeavoured to obtain an insight into the arrangement and working of the several departments of these technical universities.

In addition to twenty-one universities, Germany possesses no less than nine polytechnics, or "Technische Hochschulen," which are situated respectively in Berlin, Brunswick, Hanover, Aix-la-Chapelle, Dresden, Carlsruhe, Darmstadt, Stuttgart, and Munich. Thus the capitals of northern and southern Germany—Berlin and Munich—each possess both a university and a polytechnic. Switzerland, on the other hand, has, in addition to four universities, one polytechnic for the whole Republic, which is placed in the town of Zürich.

These institutions, like the German universities, are utterly unlike anything which we possess in the United Kingdom, for just as the universities offer an enormously wider field of studies in the department of pure knowledge than do any of our own academic organisations, so these polytechnics, limiting their sphere of action to the teaching of such subjects as are directly or indirectly connected with the arts and manufactures, offer in these practical departments such an extended programme of work as it would be impossible for a student to find elsewhere. Indeed, without a personal visit to one or more of these foci of practical learning, it is impossible for an Englishman, bred up amidst the casual and *laissez-faire* systems of education prevalent amongst us, to realise the nature of the highly organised and complicated machinery for instruction which is at work in so many centres on the Continent. Such a visit will perhaps more than anything else serve to remove that childlike faith in the unassailable pre-eminence of British institutions which, unfortunately we must confess, is so characteristic of insular ignorance and prejudice.

Many of us pride ourselves upon our great national wealth, and justly no doubt, for Mr. Giffen has recently informed us that our national capital in 1885 might be estimated at the stupendous sum of £10,000 millions; but with this knowledge of our wealth, what will future generations say as to the store we set by education, when they compare the monuments we have raised in honour of learning with those erected by our less wealthy neighbours.

You are all doubtless acquainted with some of the shrines of higher learning which grace our metropolis; you all know the soot-incrusted walls of University and King's Colleges; you have seen the red-brick and terra-cotta of the Normal School of Science, as well as the structure not very unlike a Lancashire cotton-mill, which is known as the City and Guilds of London Central Institution. These are the most striking edifices in which the higher education of London is carried on.

I will not contrast with these the educational buildings to be found in the larger German towns, such as Berlin and Munich, small as these towns are in population, and evanescent as regards their wealth in comparison with London, but we will pass to some of the smaller German towns:—

Brunswick	85,000	inhabitants.
Carlsruhe	52,000	,,
Darmstadt	48,000	,,
Aix-la-Chapelle	100,000	,,
Hanover	145,000	,,
Stuttgart	126,000	,,

These six towns, with a total population of but little more than 500,000, possess six fully-equipped polytechnical schools, any one of which would put to shame the equipment to be found in any institution having at all similar aims in the United Kingdom.

But let us arrive at a little clearer understanding as to the nature of the equipment of one of these polytechnical schools.

The arrangement and organisation of all these schools being very much on the same plan, we may take any one of them as an example. Thus, the Polytechnic at Carlsruhe, which I select at random, is divided into six distinct departments:—

	Duration of course of study.
1. Mathematics and Natural Science	2 years.
2. Civil Engineering	4 ,,
3. Mechanical and Electrical Engineering	4 ,,
4. Architecture	4 ,,
5. Chemistry	3 ,,
6. Forestry	4 ,,

In each of these departments there is a perfectly definite course of study laid down, and extending over the periods of time indicated above. It would carry me quite beyond the limits of my time even merely to enumerate the courses of lectures and of practical instruction given in these several departments. We will, however, take one department in illustration, and will select that of architecture, inasmuch as there is no sort of equivalent to this in any British school that I am acquainted with.

The four years' course of study in architecture is thus arranged:—

First Year.

Winter.	Hours per week.
Differential and Integral Calculus	4
Analytical Plane Geometry	3
Geometry.—I.	4
Practical class in ditto.—I.	3
Experimental Physics	4
Inorganic Chemistry	4
Technical Architecture.—I.	4
Architecture of Classical Antiquity and Renaissance	2
Drawing (Architectural)	6

Summer.	
Geometry.—II.	4
Practical in ditto.—II.	4
Elementary Mechanics	5
Practical in ditto	1
Experimental Physics.—II.	4
Organic Chemistry	4
Building Materials	2
Technical Architecture —I.	3
Architecture of Classical Antiquity and Renaissance	2
Drawing (Architectural)	6

Second Year.

Winter.	Hours per week.
Graphic Statics	2
Practical in ditto	2
Mineralogy	4
Technical Architecture and Calculations	3
Mediæval Architecture	2
Drawing and Design (Architectural)	10
Decorative Drawing	2
Human Anatomy and Proportions	1
Figure-drawing	2
Water-colour Painting	2
Stone-carving	6
Political Economy	3

Summer.	
Perspective	2
Practical in ditto	2
Geology	4
Elements of Practical Geometry	2
Technical Architecture and Calculation of Wooden Structures	3
Farm-buildings	2
Mediæval Architecture (Practical)	2
Drawing and Design (Architectural)	10
Decorative Drawing	2
Water-colour Painting	2
Figure drawing from the antique	4
Stone-carving	6
Science of Finance	3

Third Year.

Winter.	Hours per week.
Building (Construction)—I.	2
Building (Design)	8
Decorative (Drawing and Design)	2
Building (Works)	2
Heating and Ventilation	2
Perspective	2

Summer.	
Building (Construction)—I.	2
Mediæval Church (Architecture)	2
Building (Design)	6
Decorative Drawing and Design	4
Heating and Lighting	2
Practical Ventilation	1
Perspective	2

Fourth Year.

Winter.	Hours per week.
Building (Construction)—II.	2
Building (Design)	6
Stylistic Problems	4
Decoration (Practical)	2
Oriental and Greek Art	3
Painting of the 17th Century	2
German Law (Special Chapters)	3
Water-colour Painting	4
Figure Drawing	4
Decorative Modelling in Clay	8

Summer.	
Building (Construction)—II.	2
Building (Design)	6
Stylistic Problems	4
Decorative Drawing and Design	2
Decoration (Practical)	2
Etruscan, Roman, and Early Christian Art	3
Demonstrations in the Plastic Collection of the Grand-Ducal Museum	1
Water-colour Painting	4
Figure Drawing	4
Decorative Modelling in Clay	8

It may perhaps suggest itself to some of you that possibly this goodly array of subjects is taught by one or two of the *factotum* class, who figure in a number of different capacities, after the fashion of the omniscient and versatile teachers who cram pupils for the May examinations of the Science and Art Department; but such is not the case, the power of teaching twenty odd subjects being apparently one of those attributes of which Britons have the monopoly. The courses referred to above are, in point of fact, carried on by 22 professors and assistants, whilst the whole teaching staff of the polytechnic numbers some 68 professors and assistants.

The above curriculum is offered under one roof in a small town of 52,000 inhabitants. Is there any town in the United Kingdom which could provide the same? Nay, more, could as extended a course of study be obtained even should the student have the power of being in all the towns of the British Empire at one and the same time? We must unhesitatingly reply, "No."

The next point of interest we have to consider is the number of students making use of an institution of this kind, and for this purpose I will cite the following Table of attendance during the session 1888-9:—

Department.	Number of Students.
Mathematics and Natural Science	8
Civil Engineering	38
Mechanical Engineering	188
Architecture	34
Chemistry	99
Forestry	45
Irregular	92
Total..............	504

These numbers appear at first sight very small, and hardly to merit the elaborate and costly organisation which I have described. There are many of our British colleges which annually publish in their calendars a considerably larger attendance than the above. A little closer inquiry, however, elicits the fact that there is a most important distinction between the numbers recorded in the two cases. Thus 412 out of the above 504 students were following out the course of instruction in one or other of the several departments in its entirety, and would thus leave the school with the guarantee of having enjoyed a thoroughly systematic training in one particular department. In the case of our British colleges, however, students of that kind are quite the exception, whilst the majority only attend a few classes selected at their own pleasure, and the attendance is generally continued only for an utterly inadequate length of time. Again, students before admission to a polytechnic must show evidence of such previous general knowledge, especially of mathematics, as will enable them to derive real benefit from the classes, and prevent their reducing the standard of teaching in the same. Now, I feel no doubt that all who have had to deal with British students will corroborate me in saying that they usually come up to the colleges ill prepared, and that much time has to be wasted in, to some extent, making good their want of preliminary education, whereby the progress of the classes is greatly retarded. In point of fact, a large number of the students who come to our colleges to be prepared for practical life are by their want of school education quite unfitted for receiving any higher scientific or technical training. Indeed, there is a general sort of impression that a youth who has failed in everything else that he has attempted, is yet quite likely to fall on his feet in the study of science for a technical career. Our scientific colleges thus, instead of being frequented by bright youths of promise, are too frequently regarded as the harbour of refuge for the dull and unsuccessful. In many cases, again, the value and success of the student's career is entirely marred through the hurry and impatience of the parent, who demands that in some absurdly short period of time his son shall be specially fitted out to take up some practical and more or less remunerative occupation which he happens to be able to obtain for him.

There is yet another point to which I would draw attention, and to which I attach great importance, and this is the very large proportional number of teachers attached to the several departments of these polytechnics. Inasmuch as in Germany academic promotion is almost entirely dependent upon personal distinction in some special branch of learning, the junior staff in such institutions are restlessly active in endeavouring to gain a name for themselves in some particular domain of their science, in which they, therefore, acquire special knowledge, and which thus indirectly becomes of the greatest value to the teaching efficiency of the school, as numerous specialities can thus be taught in a manner which would be quite impossible if the entire teaching devolved upon a small staff of professors.

These remarks will serve to convey a general impression as to the nature of the polytechnical schools in the smaller German towns, and although those in the larger centres are constructed upon essentially the same plan, still, there are certain features connected with them which require special consideration.

Of the larger German towns (Dresden, Munich, and Berlin) possessing polytechnical schools, that of Dresden is on a somewhat larger scale than those to which I have referred, whilst the schools of Munich and Berlin are of altogether gigantic dimensions, both as regards the numbers of the students, and the magnitude of their teaching staffs.

From this photograph of the Munich Polytechnic you will see that the exterior of this building is worthy of the classical taste which has been cherished in that city since the days of Ludwig I., whilst the fine marble entrance-hall and majestic staircase are amongst the most imposing architectural features of this monumental capital.

But even this is thrown into the shade by the new building of the Berlin Polytechnic at Charlottenburg, than which there exists, as far as I am aware, no edifice devoted to educational purposes in the whole of Europe which can compare either in size, completeness of equipment, or in the costliness of the structural execution; it is indeed perhaps the most striking of the many noble buildings which have been raised during the past twenty years under the auspices of the German empire.

Bred up in an utilitarian country like our own, it is impossible to view these magnificent buildings without questioning the wisdom of spending such large sums of money on the mere external decoration of these schools, when undoubtedly the very same courses of instruction might be given in buildings of a much less pretentious character. True as that may be, however, it must be borne in mind that there is an innate tendency in human nature to beautify and adorn that which we respect and of which we are proud, and in all ages and countries it is not difficult, by taking note of the objects which have been most lavishly adorned, to discern in what direction the feelings of reverence and pride have been turned. The temples of the Greeks, the amphitheatres, villas, and palaces of the Romans, the churches of the Middle Ages, upon all of which in turn vast sums of money have been expended, are the most infallible records of national aspiration and interest in the past. If, then, we find that in a comparatively poor country like Germany handsome and costly buildings are being erected at the public expense for purposes of education and culture, whilst in the richest country of the Old World there is hardly a building of the kind to be discovered, the only conclusion that can be drawn is that in the one country education and culture are highly prized and revered, whilst in the other they are held of but little account, and are considered unworthy of any mark of public respect.

In the following Table I have recorded the attendance of students in the various departments of the several polytechnical schools, as well as the number of the teaching staff attached to each of these institutions.

TABLE I.—Number of Students and Teaching Staff at Polytechnic Schools.

	Berlin.	Münich.	Dresden.	Hanover.	Stuttgart.	Aix-la-Chappelle.	Brunswick.	Carlsruhe.	Darmstadt.	Zürich.
Architecture	180	73	59	27	60	28	8	34	35	20
Civil Engineering	181	97	55	80	17	24	12	38	26	166
Mechanical Engineering	407	158	116	84	61	81	54	188	132*	194
Chemistry	105	77	105	25	78	111	45	99	41	157
Agriculture or Forestry	..	11	..	..	..	..	..	45	..	59
Mathematics and Natural Sciences	..	80	11	2	20	..	46	8	14	42
Regular Students (total)	873	496	346	218	236	244	165	412	248	638
Irregular Students	419	290	163	200	38	22	100	92	76	359
Total attendance	1,29	786	509	418	274	266	265	504	324	997
Teaching Staff	104	75	57	56	56	57	41	68	45	113

* Includes 86 students of technical electricity.

I have further collected some particular concerning the Zürich Polytechnic, which may be of interest; viz., the extent to which the various nationalities are represented in this most cosmopolitan school, and the annual expense of its maintenance.

TABLE II.—Zurich Polytechnic (1888-9).

	Students.
Switzerland	261
France	9
Germany	41
Austria-Hungary	57
Italy	48
Netherlands	11
Great Britain	7
Denmark	6
Sweden-Norway	6
Russia	104
Spain-Portugal	1
Turkey	6
Servia	2
Bulgaria	9
Roumania	37
Greece	15
America	18
	638

From this Table it will be seen that the advantages offered by this school are only very slightly appreciated by Englishmen, inasmuch as the British contingent of students is amongst the smallest, being only greater than that of such countries as Denmark, Norway, Sweden, Spain, Portugal, Turkey, and Servia.

TABLE III. — Expenditure of Zurich Polytechnic.

	Francs.	£
Management	93,800	3,752
Salaries of teaching staff	380,700	15,228
Professors' share of students' fees	32,900	1,316
Museums, &c.	126,400	5,056
Prizes	590	23
Maintenance of fittings	5,000	200
Miscellaneous	4,200	168
	643,590	25,743

As regards the instruction which is imparted in these polytechnical schools, it must be noted that this is essentially of an academic character, and that we do not find in them those classes for manual instruction which some of our own doctrinaires conceive to be the essence of a technical education. These schools are not intended to turn out men immediately capable of running a cotton mill, an engineer's shop, a soap works, or a whiskey distillery; Germany has other schools, in which special attention is given to the practical details of many industries, and the object of the polytechnics is to train up men of high culture, but of such culture as is calculated to be of the greatest utility in the various branches of industrial life. They are in fact technical universities, although this term is doubtless likely to give offence to or rather arouse the scorn of those who, unacquainted with the modern developments of science, cannot conceive of true university teaching having any relationship to the practical requirements of an industrial age.

If, then, these polytechnical schools are essentially of a university character, the question naturally arises as to the wisdom of having severed them from the old universities proper; indeed, there is a feeling amongst many in Germany that if these schools were being established afresh they would be made to form part of the universities, and it is obvious that such a step would be attended with many very great advantages. In the first place, a very considerable economy would be effected by avoiding the unnecessary duplication of chairs and classes, many of the ordinary university classes thus, notably those in mathematics, physics, and general chemistry, being equally suitable for the polytechnical students. Indeed, in Berlin, Munich, and Zürich, where the university and polytechnic exist side by side, a considerable amount of mutual accommodation takes place, thus, especially in the department of chemistry, owing to the congested state of the university laboratories, university students frequently work in the laboratories of the polytechnic; whilst, on the other hand, polytechnic students often take such university classes as will complete their qualifications for the degrees which the universities can alone confer.

In our own country, I believe that the extension of university teaching in the technical direction would be a step of the profoundest importance, and one which is most earnestly to be desired. In the first place, our ancient universities of Oxford and Cambridge enjoy such a prodigious prestige that it is hardly an exaggeration to say that, since the abolition of the religious tests, they are frequented by almost all young Englishmen able to afford, and, for the matter of that, by a great many also whose parents are certainly unable to afford, the expense which they entail. They are thus frequented by a great number to whom the particular kind of teaching they provide is but of little value, if not entirely useless, and who could certainly receive instruction far better suited to their future wants elsewhere. Hitherto, all the more modern places of higher education have been unsuccessful in breaking down this prestige, with the result that, admirable as many of these newer institutions are, they absolutely fail to draw into their fold the very men for whom they were founded. Thus, to take a concrete example, there is surely no class of men to whom a higher practical and scientific education should be of greater value than to the sons of manufacturers, yet this very class, if they aspire to any higher education at all, generally select the universities of Oxford and Cambridge, with their ancient systems of training, which only too frequently engender in them a feeling of distate and repulsion for the practical career which circumstances require that they should pursue, and for which a polytechnical training would have excited a higher and ennobling interest, by revealing the many important scientific bearings which even the most monotonous and wearisome industrial processes usually possess. In addition to this, the polytechnical training would render such men of immensely greater value in their various lines of business; it would open up their minds to the possibilities of modification and extension, and make them more independent of the skilled assistance which they are now constantly obliged to consult in the dark.

By developing university teaching in the technical direction this existing evil would be largely counteracted, for whilst the higher status of the universities, and especially their great social advantages, will doubtless continue to draw the most highly endowed of each rising generation, that increasingly large section of the latter who require the highest preparation for modern industrial life would in these universities themselves find the necessary curriculum for such qualification, whilst the university degree, which popular prejudice still recognises as a badge of culture, would be extended not, as at present, only to those who have received what may be quite accurately denominated a technical education for the church, the law, or for medicine, but also to those whose university training had been calculated to fit them for the equally intellectual exercise of many industrial callings.

Indeed, it must not be forgotten that the universities themselves have already conceded this development to a certain extent; thus at Cambridge there is higher teaching in the department of engineering, whilst at all the Scotch universities a science degree is obtainable in this essentially technical department. It is earnestly to be hoped that a further extension of this principle in the case of other departments of applied science, *e.g.*, in civil engineering, architecture, technical chemistry, and agriculture will be brought about. Moreover, in the constitution of a new university out of already existing teaching corporations, as is contemplated in the case of the teaching university for London, it seems to me that it would be a most calamitous mistake if such bodies as the Royal School of Mines and the City and Guilds Institute, engaged as they are in higher technical or semi-technical teaching, were not included and made to form a part of the university organisation.

Before leaving the subject of the German polytechnical schools, I should like to mention that in none of these is there to be found the system of evening classes which form such a conspicuous feature in many of our British colleges, and which, admirable as their original idea was, have in actual practice led, in my opinion, to a most serious miscarriage of higher technical teaching. Such evening classes were originally of course intended for the instruction of artisans and others, who from sheer necessity would be unable to take advantage of the ordinary day-teaching. Against the existence of such evening classes I have not a word to say, provided it is fully understood that their scope must necessarily be very limited and elementary; unfortunately, however, as these classes are carried on by the same body of men as the day classes, the idea has largely gained ground that the one set of classes is merely a compressed duplicate of the other, and capable of yielding the same advantages, the evening classes having the special attraction of yielding these imaginary benefits with a very much less expenditure of time, and, what is doubtless still more to the point, for a considerably smaller fee. It is thus only too frequently found that men are attending such evening classes whose means, position, and opportunities demand that they should take the fullest advantage of the regular day-courses which are provided at their very doors.

The higher technical or polytechnical education to which I have referred is thus intended rather to provide a high standard of practical culture for the man intending to enter upon an industrial career than to teach him the details of any particular trade. Such details can in general only be obtained in factories and workshops themselves, although in some cases perhaps this kind of practical training may be supplemented by special trade schools.

Of such trade-schools perhaps the most remarkable is the one at Crefeld, which is devoted to the teaching of all branches of the textile industries. Being myself particularly interested in technical teaching in connection with the textile industries, I made a point of visiting Crefeld with a view to acquainting myself with the internal arrangements of this celebrated institution. My visit to this industrial centre, undertaken at considerable personal inconvenience, was rewarded with disappointment and annoyance; in fact, my inspection was practically limited to what I have now the pleasure of bringing before you in the next photograph—the very handsome exterior of the school building itself.

On presenting my card at the door, I was referred to the directorate, where I was treated much as though I had been an emissary of some English firm trying to appropriate the trade secrets of a German factory. I was, in fact, informed with a certain want of ceremony, if not of courtesy—which prosperity and Chauvinism are rendering characteristic of an increasing section of the subjects of the Hohenzollerns—that for some time past no foreigners were, under any pretext whatever, admitted to the school. I soon found that such persuasive power as I possessed was entirely valueless, and that in point of fact it would be as easy for a camel to pass through the eye of a needle as for a foreigner to insinuate himself into the mysteries of this trade school. Through the consideration of the attendant who conducted me to the door, and whose courtesy certainly exceeded that of his master, I was, before leaving, enabled to partially gratify my curiosity by a cursory inspection of the very fine museum of textile design, as well as of some of the fabrics manufactured in the school itself, and which certainly afforded a most brilliant testimonial to the practical and serious nature of the work done in the school.

I have since been able to greatly amplify my knowledge of this interesting and remarkable "teaching factory" through a very full description of it which recently appeared in the *Färber Zeitung*. The school was originally started on a very modest scale in the year 1855, but through the instrumentality of the Crefeld Chamber of Commerce it has, since 1878, greatly extended its sphere of action, and from 1883 five-eighths of its cost has been defrayed by the State, and the remaining three-eighths by voluntary contributions, chiefly in Crefeld itself. The school now enjoys the title of the "Königliche Webe-Färberei und Appretur-Schule," and furnishes a complete course of instruction, practical and theoretical, in all the departments of weaving, dyeing, and finishing. To give you an idea of the completeness of the equipment, I may mention that the weaving-sheds contain no less than 125 looms arranged for exhibiting the most varied methods of weaving even the most complex patterns in silk, wool, cotton, linen, and jute. The school also executes special orders in these departments, and in the museum I myself saw a magnificent rich damask material which had been ordered by the Emperor of Germany, for the adornment of a room in one of his palaces.

Of other German technical schools giving instruction in the details of special industries may be mentioned the brewing and spirit distilling schools of Berlin and Munich. Both of these institutions I visited with the greatest interest, and was received with a geniality which was in keeping with the traditions of the particular department of industry they represented. These institutions are not only intended for the instruction of young brewers and distillers, but also for the investigation of all questions which may arise in connection with brewing and distilling. It is in their laboratories that the methods of pure yeast culture, originally inaugurated by Hansen of Copenhagen, have been carried on and further extended, and an increasing number of breweries all over the Continent are now drawing regular supplies of pure yeast prepared in these institutions. Here again, as at Crefeld, the expense of these institutions is borne partially by the State, and partially by private subscriptions.

On comparing the opportunities for technical education in Germany and Switzerland with those in this country, we cannot fail to be most forcibly impressed with a sense of our inferiority.

Corresponding with the magnificent state-supported polytechnical schools of the Continent, we have only the various local colleges endowed by private persons, and towards the support of which the shabby sum of £15,000 per annum has with difficulty been wrung out of the Treasury. The utility of these colleges is not only crippled in many cases by want of funds, but also through the entire absence of organisation which prevails in respect of higher technical training. We require the preparation of a definite qualifying curriculum for the various departments of technical activity, and such curricula must become recognised by public opinion, must carry with them some badge or degree, which should be more especially taken into consideration in the case of all State appointments.

We require a more distinct differentiation between the several grades of technical teaching. It must become understood that the training required by a future master manufacturer should be very much more complete, and more scientific in its scope, than the training of a mechanic or artisan; and that whilst the latter may doubtless obtain what he wants by a carefully selected series of evening classes, the adequate training of the master can only be obtained by a much more comprehensive course of study. Indeed, in my opinion, the most immediate want in higher technical education is not the foundation of new schools, and hardly the further equipment of those already existing, but the awakening of the individual to the necessity or desirability of this higher training. At the present moment the various schools provide a great deal more than is demanded of them. In many cases classes of a high standard, taught by professors of great ability, are thinly attended, and in some cases have actually to be abandoned owing to the lack of students. The schools have, in fact, been developed beyond the demands of the students. As Sir Henry Roscoe has so truly remarked, "the demand for technically-instructed persons in this country has yet to be created." As long as unqualified and imperfectly-educated persons are so frequently appointed to positions of power and responsibility, to the exclusion of the fully-qualified and educated; as long as interest and personal connections generally carry further than personal distinction, there is little hope of candidates for such positions seeking more than a minimum qualification, and it is almost useless to offer a higher training which the candidate fears may prove to have no marketable value. It is a most regrettable national characteristic, but one to which we must not shut our eyes, that few of us care to bestow time and trouble upon anything which is not sooner or later to prove remunerative. For culture without material reward we have little taste; and in spite of the immensely extended opportunities of obtaining culture which the last quarter of a century has brought forth, there is but little evidence that this national characteristic has altered. The leopard has not changed his spots.

How to stimulate a desire for culture, irrespective of gain, amongst our own countrymen is a problem perhaps as difficult as that propounded by the sphinx; but surely nothing can operate more forcibly towards its ultimate solution than a widespread realisation of the low position which we undoubtedly now occupy in the scale of European education and culture; and it is in the hope of assisting, however slightly, in extending a knowledge of our inferiority, that I have ventured to bring this paper before you to-night.

DISCUSSION.

Sir Henry Doulton said he entirely agreed with all that had been said as to the necessity of higher education, and to the connection of the universities with this kind of culture, and it appeared to him that what was wanted in England were such opportunities of training the men engaged in commerce and manufactures as that afforded by the higher universities for the liberal professions. But it was a serious question if these opportunities were to be afforded by Government. The photographs which had been exhibited represented magnificent buildings which must have cost vast sums of money, provided by the State; but the State had not a bottomless purse, and the money must come out of the pockets of the people. It appeared to him to be a question whether the way in which these institutions were naturally arising in such towns as Manchester, Liverpool, and Birmingham, by the liberality of individuals and municipalities, was not the more healthy one. Professor Frankland told them that it had already been questioned whether it would not have been better if these institutions had been connected with the universities which were devoted to the higher culture of the people, and he could not help feeling that there was a little undue depreciation of English methods and modes of operation. There was not that freedom, that originality, and spirit of enterprise which had always been associated with English inspirations and accomplishments. He did not quite agree with Dr. Frankland as to the low place which England occupied; and, at any rate, the position she had won had been achieved by individual exertion. He could not help pitying those Carlsruhe students when he heard of the four years course they had to go through, and could not help thinking of a story told of the Rev. Robert Hall, the celebrated Nonconformist preacher. Someone said to him what a learned man Dr. Kippis was, and he replied "Yes, he has laid so many books on his brains that they are unable to move." This kind of training might be carried too far. Too much importance could not be attached to the study of pure science, and it might, with advantage, be connected with the universities, but as to the mass of the people, he was not so sure that it was wise to seek to make them continue in the evening that toil which was so engrossing during the day. He was inclined to think that while opportunities of instruction should be afforded to those who wished, elevating recreation was much more required for the mass of the people, and he believed there would be more demand for that than for evening educational institutions.

Dr. ALDER WRIGHT, F.R.S., said, as an Englishman, he felt somewhat ashamed of his country when he heard what was being done abroad in connection with the advancement of the higher education, and he could only hope that the seed which was now being sown in so many quarters would speedily bear fruit, and that we might no longer be ashamed to compare our own position with that of Germany or Switzerland. In the early part of the paper, there was a remark to the effect that it was eminently desirable that technical education, not perhaps of the highest type, but more suited to our artisans, should be preceded by some sort of scientific training of a collegiate character; but it unfortunately happened that, in many institutions where attempts had been made to give instruction in applied science, great difficulty had been experienced in getting educated teachers. A teacher who had simply been trained in scientific establishments was not very apt to appreciate the wants of a factory. He was thinking more of chemical work than of anything else, having been connected with that department, and it had occurred to him several times in the last few years, while looking round at the results of classes established for the teaching of technical chemistry, especially in connection with the examinations at the City Guilds, that the training given was too much of the educational character. The teachers as a rule had not been through the mill themselves; and while they could explain in clear language what they found in text-books, when you came to ascertain what real knowledge of the processes the student had gained, you often were disappointed to find how little sound practical knowledge they had acquired of subjects supposed to be taught. This arose largely from the fact that the teacher was often incapable of bringing out those more technical bearings which he conceived were mainly wanted in classes of that description. For the purpose of training teachers, a university technical education such as had been described was admirable, but even then it required, in order to make an efficient teacher, to be supplemented by the actual experience in a factory, otherwise the teacher would be apt to train up students in the same way as a crammer, rather than to make them useful members of society. The University of Zürich, so far as technical chemistry went, was an excellent example of the advantages of actual practical work, for he doubted whether Professor Lunge would have been so successful as he had if he had not been for some years a successful alkali manufacturer.

Mr. J. EMERSON DOWSON said Dr. Frankland had referred in rather strong terms to the reasons why he thought the manufacturers of this country did not support higher education more than they did, but he should be sorry to adopt that view entirely. He thought it was rather that the subject was not sufficiently understood. Technical education had been so much mixed up in its definition with the popular craze for recreative schools for the working classes, that a great deal of misunderstanding had arisen, and he did not think it was fair to attribute our deficiencies to the lowness of view of any particular class in the community. There were two distinct things which often got confounded; one was technical instruction in relation to the improvement of our manufactures; and the other the promotion of technical instruction as a complementary education for those chiefly in the primary schools. It was said by some that if we gave technical instruction to the lower classes it would indirectly improve our manufactures, but he thought that would be so to a very slight extent indeed. Improvements in designs and processes depended on very much more than elementary knowledge; and if we wanted to compete successfully we must follow out the lines adopted on the Continent, such as had been put forward that evening. Training in manipulation was essential, but it would never give that improvement in designs and processes which was required to put us on a better footing in foreign competition. The evidence in the Report of the Royal Commission went to show that foreign designers and directors of labour were much more advanced, and, as had been shown, they had much better opportunites of obtaining knowledge. It was a great mistake to turn aside on the side issue of creating recreative schools, and calling them polytechnics. Dr. Frankland said there were, probably, schools in sufficient number for present purposes, but they were not taken advantage of. He had an idea that this arose partly because there was too much pure instead of applied science, to suit the needs of the manufacturers. There was no disguising the fact that very often manufacturers had not themselves had a scientific training, and did not sufficiently appreciate its importance to those about them.

Mr. H. TRUEMAN WOOD said the Society was much indebted to Dr. Frankland for the able way in which he had brought this subject before it. On former occasions British educational institutions had been rather held up to scorn, in comparison with those of other countries; but they had never had the subject brought forward in so practical a way, the actual buildings erected for this purpose in foreign countries being brought so vividly before them by the photographs shown upon the screen. Dr. Frankland might have much enlarged his collection if he had crossed the Atlantic, and brought back views of some of the buildings there, such as the Massachusetts Institution of Technology, and other buildings erected in recent years. This question of buildings was one requiring a great deal of consideration, for in England we were shamefully niggardly in this matter. For years South Kensington, which was the admiration of Europe, was left unfinished, until it was beginning to lose the character of a museum and assume that of a lumber room. The Natural History Museum had an excellent front, but it seemed likely to lack a back and sides for many years. We did not seem to appreciate the importance and even economy of good buildings which would last for centuries. British financial arrangements were singularly well adapted for wasting money on objects of absolutely no importance, while preventing its expenditure on worthy objects. Of course it was the fault of the State, but after all the State was only the servant of the public, and if public opinion were properly enlightened, the authorities would be forced to expend the public money more wisely. He regretted that Dr. Frankland had taken such a pessimistic view of this country in the paper, which would have been more appropriate ten or twelve years ago. He had given no credit for the large sums which had been spent in the promotion of technical education, both in the country and in London, by the munificence of the City Guilds and other bodies, so that in all the great cities, one after the other, educational institutions were springing up and maturing in the best and safest of all possible ways. It was by far the more scientific method that there should be a certain variety of experiment, that the work should be undertaken in a number of different ways, hoping for the survival of the fittest. This had been going on for some ten years, and was still going on, and there was every sign that the cause of education was by no means going back. He must protest against what was said about the position of this country in European estimation, and could not admit that we took a low rank either in arts, letters, or sciences. At the great Exhibition in Paris last year we had not a fair field, and very little favour, having to compete under very great disadvantages; but nevertheless we made the best show of any foreign country there represented, whether in industries, in art, or in science so far as it was represented. Dr. Frankland had rather expressed regret at the partial survival of the old apprenticeship system, and in that he could not entirely agree with him; and many who had the widest knowledge on these points did not hold the same view. It might be so with regard to the higher technical education, but he thought by giving up the apprentice system we failed to utilise to the full the imitative faculty of children, by which all insensibly learned so much of what they knew.

Mr. A. L. JONES asked if there were any arrangement in the Continental countries between the large manufacturers and the government or heads of colleges, by which those who had passed through these extensive courses of instruction received appointment, or whether they were left, as they would be in England, to free competition.

Mr. H. STANNUS asked what institution bore out the remark that the power of teaching twenty different subjects by one person was a British monopoly.

The CHAIRMAN then proposed a cordial vote of thanks to Dr. Frankland for his very able paper, and for the extremely interesting way in which he had placed the subject before the meeting. The discussion, although not very long, had been valuable, and he hoped both the paper and the discussion would be carefully studied in print, and lead to useful results. One point of great practical importance was the necessity for practical knowledge by teachers. In some technical schools in this country a good deal was taught about different subjects, but it seemed to him that the subjects themselves were not taught. The students learned a good deal of book knowledge, and how to deal with little models, but they had no knowledge of how to treat practically those matters with which they afterwards had to deal.

Prof. PERCY FRANKLAND, in reply, said that the Carlsruhe students might be pitied from one point of view, as Sir Henry Doulton suggested, inasmuch as all people who had to work hard might excite sympathy; but our English students generally did not work hard enough, and those who did often worked in the wrong direction. He was of opinion that all Englishmen would have to work harder than at present, and that instead of an Eight Hours Bill, he would suggest that there should be an Act for extending the hours of labour, at any rate of some classes. We had in the past enjoyed an exceptional position, for we had reaped the benefit of the dissensions and wars on the Continent, but now that peace had been enjoyed for 20 years, we were beginning to feel the pinch of competition. He quite concurred in the remarks of Dr. Alder Wright and the Chairman with regard to the desirability of technical teachers having practical knowledge, but unfortunately it was very difficult to find teachers who were both thoroughly trained theoretically in the various sciences and also in the practice of some industrial process, and still more difficult was it to find men who were adequately informed on a number of such processes. Even Professor Lunge's practical experience was probably limited to the alkali manufacture, but he had to deal with numbers of others. Practical technical teaching in the various industries could never, therefore, be provided in one school. They wanted schools where pure scientific training was given, and special schools, such as that at

Crefeld and the others he had referred to, for practical teaching. There were many such schools in this country. At Bradford there were excellent schools for engineering and the textile industries. It was quite true that much confusion existed on the subject of technical instruction, and it was a great error to suppose that the same kind of teaching was required for the artisan as for the manufacturer. That of the artisan should be of a practical character, to give him a more general survey of practical work than he could get in one workshop, whilst the master ought to be fully trained in the theory and wider bearings of the subject. Reference had been made to the institutions, which were growing up in this country, called polytechnics, which was a most mischievous name, like the so-called "university extension" teaching. These university extension lectures consisted of short courses, which were delivered in the suburbs and in small towns, and people who had no sort of previous training attended them, and imagined that in some mysterious way they formed part of the university. In the same way people went to polytechnics, listened to music, and developed their muscles on parallel bars, and imagined that they were in some way connected with a school for higher technical training, as the word polytechnic was intended to indicate. These places ought to be known by their proper names; they served a very useful purpose, but they were not to be confounded with places of education and culture. With regard to the decay of the apprenticeship system, he had not intended to deal with it in the case of artisans, as to which he did not possess sufficient knowledge; but in such callings as engineering and architecture, he was quite sure the existing principle was a bad one that a man should go and spend five years in a shop. It would be all very well if they had some higher training either before or after, but as a rule they did not; they went straight from school to the shop, and enjoyed no higher training at all, which necessarily limited their powers. It did not prevent a man of exceptional ability rising to the same position as an engineer who enjoyed the best education; but nothing was more fallacious than to judge of institutions by exceptional cases; they were intended for average mankind. He had been accused of holding a pessimistic view, but he should be very glad to abandon it if he saw any adequate cause. No doubt during the past 20 or 30 years an immense amount had been done for education, and was still being done, by private effort, but he doubted whether the question could be effectively dealt with by private enterprise. It was all very well to say it was more healthy, but where could you draw the line? Were you to have the defence of the country entrusted to private enterprise? The volunteers were an excellent institution, but he should not like to trust the defence of the country to them entirely. So with education. He thought it should be undertaken by the State, being of such great national importance. It was already taken up by the State in the elementary branches, and why should it not be carried right through? He did not want to ignore—he thoroughly appreciated—what had been done by private enterprise, but he thought more of it should be done from headquarters. In reply to Mr. Jones's question, he might say that in many industries in Germany, notably the chemical, it was not uncommon to take any young man from one of these institutions who was fairly recommended, with a small salary, or perhaps none at first; his ability was tested for a year or two, and if he were no good he was dismissed, but if he were any good he would get on, and his chances in a German manufactory were much better than in an English one. This was especially the case in the colour industries. He believed he was justified in saying that there were, at the present moment, many teachers who were qualified, under the regulations of the Science and Art Department, to teach upwards of twenty subjects. It was very easy to obtain the qualification, and there was no reason why a man should not pass in twenty subjects, and if he passed he was qualified to earn grants for the classes he taught. In conclusion, he would say that it was a great pity to look at this question solely from a mercantile point of view. Competition of course must be taken into account, but there ought to be a higher aim also in developing education. It was necessary for the individual that he should cultivate himself, quite irrespective of what he might gain by it.

Miscellaneous.

EUROPEAN EMIGRATION IN 1888.

M. Paul Leroy Beaulieu, writing in the *Economiste Francais*, says that European emigration, after attaining considerable proportions during the period comprised between the years 1880 and 1883, showed a decided falling off from the latter year to 1885 or 1886, while it again increased in volume dating from the year 1887. In 1883, European emigration, leaving Austria-Hungary and Russia out of the question, rose to about 680,000 persons, according to the returns published by the official bureaus of the various countries of departure, which are usually rather below than above the mark, one reason being that a considerable amount of secret emigration takes place, and this escapes official registration. In 1885, European emigration, officially recorded, fell below 490,000 persons, or a diminution of 190,000 compared with 1883. Since 1887, on the other hand, there appears to have been a decided impetus given to emigration, as in that year the number of persons officially recorded as leaving Europe amounted to 672,000. In 1888, returns are wanting for the Netherlands, Spain, Portugal, Sweden, and Norway, but as there is a noticeable increase in emigration that year as compared with 1887, as regards Italy, France, and

Switzerland, and it remained at about the same figure in Germany and the United Kingdom, it may fairly be assumed that emigration in 1888 rose to between 750,000 and 760,000 persons. If Austro-Hungarian and Russian emigration were added to the above, a figure very nearly approaching 840,000 would be obtained. It results therefore that there was an increase in emigration in 1888 over 1883 or 1884 of nearly 200,000 persons. As regards the currents of emigration, they have been subject to considerable modification during the last ten years. At one period—namely, in 1880 or 1881—emigration from the Teutonic, Anglo-Saxon, or Scandinavian countries was directed to the United States, Canada, and Australia, the English-speaking countries, and these were practically the only ones that benefited by the efflux. In 1880, Italian emigration only amounted to 35,000 persons, and it was directed chiefly to the neighbouring European countries; French emigration officially registered did not exceed 4,612; Portuguese 12,597; and Spanish between 15,000 and 20,000. Adding to these the emigrants from the provinces of the Austro-Hungarian Empire who belong to the Italian race, a figure of 80,000 is arrived at as representing the total emigration of the Latin race. Since, 1885, however, there has been a decided increase in the emigration of the Latin, and in 1888 it nearly approached that of the Teutonic and British races, as the following approximate figures show:—Latin races, emigration from Italy in 1888, 207,795 persons; France, 23,339; Belgium, 7,794; Spain, 37,202; and Portugal, 17,518, making a total of 293,649. As regards the Teutonic and British races, the emigration from Germany amounted to 98,515 persons, and from Great Britain and Ireland to 279,928—in all, 378,443 persons. In the case of Spain the above figures relate to the year 1887, and for Portugal the figures quoted are those for 1884, these being the latest years for which official returns are available, but, as M. Leroy Beaulieu says, there is no doubt that the actual figures for 1888 will be found to be in excess of those above stated. As regards the countries of destination, the following shows the number of immigrants into the principal countries of South America and into the United States in 1888:—South America, Argentine Republic, 155,632; Brazil, 131,837; Uruguay, 17,407, making a total of 304,876, while the number of immigrants into the United States during the same year amounted to 525,019. It is impossible to give the number of immigrants into Canada, as the majority only pass through that country *en route* for the United States. Admitting that the United States and Canada together receive 600,000 immigrants, there are still more than 300,000 absorbed in South America, and no note has been taken of Chili, Central America, and Mexico, returns on the subject of immigration into these countries not being easily obtainable. Countries other than those of America only receive a small stream of immigration. Australia, with 61,000 immigrants in 1888, is the only country, exclusive of North and South America, which appears to exercise any great attraction for emigrants. As regards the Cape of Good Hope and Natal they figure in official returns for 7,705 persons; the whole of Africa only attracted 159 Germans in 1888. The number of Europeans who are now drawn to the English Colonies in South Africa, or to the independent States, by the diamond and gold mines, cannot be less than 15,000 or 20,000. If a great part of the European emigration is directed towards the countries of the Latin race it will not, says M. Leroy Beaulieu, change in any appreciable proportions the elements of the populations of these countries. It is particularly the representatives of the Latin races who establish themselves in South America, and not Anglo-Saxons or Germans, the latter class of emigrants not repairing there in any great numbers. For example, in 1888, the Argentine Republic received 155,632 immigrants, of whom 26,517 arrived by way of Uruguay, and 129,115 came direct. The distribution of the latter only according to nationality is recorded. There were 75,029 Italians (that is about three-fifths of the total), 25,485 Spaniards, 17,105 French, 3,201 Belgians, 201 Portuguese, 1,479 Swiss, 2,333 Austrians, 1,536 Germans, 1,426 English, the remainder being composed of various nationalities. Thus the Anglo-Germanic element only constitutes a very small proportion. As regards Brazil, out of the 131,837 immigrants who landed in 1888, 18,289 were Portuguese, 104,353 Italians, 4,736 Spanish, 1,156 Austrians, 1,082 Belgians, 782 Germans, 478 French, and 129 English. The small number of German, French, and English emigrants to Brazil is particularly noticeable.

THE COMMERCE AND INDUSTRIES OF GREECE.

The *Journal de la Chambre de Commerce de Constantinople* says that in spite of the special aptitudes of the Greek people for commerce and industry, the country itself does not seem to be making sufficiently rapid progress. By reason of its geographical position alone it ought already to have attained a much higher degree of commercial and industrial development. The imperfect systems of cultivation and other disadvantages are the principal obstacles in the way of the country's progress. Few of the districts in Greece are fertile, and barely 53 per cent. of the area of the country is productive, and in those districts which are productive, or, which might become so, there is an absence of irrigation. The principal articles cultivated are currants, which, for the most part, are exported to England and France; then come grapes for wine-making, olives, mulberries, and tobacco, special efforts being directed to an improvement in the cultivation of the latter; finally a small quantity of cotton is produced. The mining industry of Greece is comparatively insignificant by reason of the absolute want of coal, and also of the necessary capital for working. There are, however, in the country rich mines of lead and iron. A French company is working with considerable success the Laurium argentiferous lead mines. The marble of the islands of the Archipelago have a considerable reputation, but the production is not maintained up to the old standard. A sulphur mine which yields about six hundred tons annually is worked at Milo, and there are many other small mines of this kind in various parts of Greece. Clay and its products are found in great abundance. As regards its manufacturing industry, Greece receives almost all its manufactured articles from France, Austria, and England, but strenuous efforts are being made to alter this condition of affairs, and considerable attention is at present being paid to the leather industry and to naval construction. Cotton tissues, straw plaits, pottery, oil, soap, and essences are generally the products of native industry. The principal manufacturing centres in Greece are Athens, the Piræus and Larissa. The principal commercial centres are Athens, the Piræus, Syra, Patras, Hydra, Spezia, Corfu and Volo, which are in communication with Constantinople, Salonica, Smyrna, Alexandria, Crete, Marseilles, Trieste, Malta, and Odessa. The principal articles of export are currants, almonds, figs, oil, tobacco, wine, silk, leather, gall-nuts, marble and lead. The principal articles of import are cattle, skins, fur, grain, colonial products, timber and wood for building purposes, coal (which is supplied by England), and all other manufactured articles, such for example as tissues, wearing apparel, instruments, shoes and hardware. The foreign trade of Greece is chiefly carried on with Turkey, Austria, Hungary, France, Italy, England, and Russia. As regards the isle of Eubœa, the town of Chalcis is one of the most backward of the commercial and industrial towns, but in other parts of the island the vine is cultivated with some success, and the wine produced is in considerable demand by European merchants for blending purposes. It is at Koumi that the greatest advance has been made in viticulture, which is daily assuming greater importance, and large quantities of wine produced in this district are exported to various European countries. There are also at Koumi two large flour mills worked by steam. At Chalcis there is an alcohol distillery, a cotton thread and wadding factory, and a tannery. The silkworm is also a product of the island of Eubœa. At Koumi various home industries are engaged in, such as the manufacture of silk tissues, scarves, and foulards. According to the latest official trade returns of Greece, the value of the total imports into the country in 1888 amounted to £4,976,000, and the exports to £4,126,000.

General Notes.

Berlin Medico-Scientific Exhibition.—In connection with the tenth International Medical Congress, to be held this year at Berlin, it is proposed to hold an International Medico-Scientific Exhibition, from the 2nd to the 11th of August. The Exhibition will contain instruments and apparatus, materials and preparations, models, statistical tables, maps, &c., illustrative of medicine, pharmacology, hygiene, &c., as well as specimens of medical literature.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings, at Eight o'clock:—

MAY 14.—Dr. J. A. FLEMING, "Prof. Elihu Thomson's Electro-Magnetic Induction Experiments."

MAY 21.—J. G. GORDON, "The Mannesmann Process for making Seamless Tubes." SIR FREDERICK BRAMWELL, Bart., D.C.L., F.R.S., will preside.

FOREIGN AND COLONIAL SECTION.

Thursday afternoon, at Five o'clock:—

MAY 15.—C. WASHINGTON EVES, C.M.G., "Jamaica and its Forthcoming Exhibition." C. M. KENNEDY, C.B., will preside.

Tuesday afternoon, at Five o'clock:—

MAY 20.—A. LASENBY LIBERTY, "The Industrial Arts of Japan." Sir GEORGE BIRDWOOD, K.C.I.E., C.S.I., will preside.

INDIAN SECTION.

Thursday afternoons, at Five o'clock:—

JUNE 12.—SIR THEODORE C. HOPE, K.C.S.I., "The Rationale of Indian Railways." The MARQUIS OF RIPON, K.G., will preside.

[This meeting has been postponed from May 22, as previously announced.

APPLIED ART SECTION.

Tuesday evenings, at Eight o'clock:—

MAY 13.—Prof. W. C. ROBERTS-AUSTEN, F.R.S., "The Use of Alloys in Art Metal-work."

CANTOR LECTURES.

Monday evenings, at Eight o'clock:—

RICHARD BANNISTER, "Sugar, Tea, Coffee, and Cocoa, their Origin, Preparation, and Uses." Four Lectures.

LECTURE III.—MAY 12.—*Tea*—History—East India Company's monopoly—Duties—Adulteration—Tea plant varieties—Composition of tea—Indian and Ceylon tea—Specimens.

LECTURE IV.—MAY 19—*Cocoa*—History—Origin—Preparation for market and consumption—

Composition—Commercial cocoas, nibs, soluble, extracts—Chocolate and chocolate creams—Chart showing consumption of sugar, coffee, tea, and cocoa—Specimens of cocoa, chocolate, and creams.

ADDITIONAL LECTURES.

Thursday evenings, at Eight o'clock:—

LEWIS F. DAY, "Design applied to Wood-Carving." Three Lectures.

LECTURE III.—MAY 15.—The circumstances controlling design—Its application to specific purposes—Panels, pilasters, columns, caps, friezes, mouldings—Style and the styles—The Transitional period—François 1er, &c.—The Renaissance—Arabesque and grotesque, cartouches, strapwork, wreaths, &c., their use and abuse—The florid design of a later period—The French styles—Practical hints on the study of style.

The regulations for admission will be the same as for the Cantor Lectures, each member having the privilege of admitting a friend.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MAY 12...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Richard Bannister, "Sugar, Tea, Coffee, and Cocoa, their Origin, Preparation, and Uses." (Lecture III.)

North-East Coast Institution of Engineers and Ship-builders, Newcastle-on-Tyne, 7½ p.m. 1. Adjourned discussion on Mr. Bergström's paper, "The Structural Strength, &c., of Cargo Steamers of Different Types." 2. Discussion on Mr. Boyd's paper, "The Weight of Machinery in the Mercantile Marine."

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Hon. G. Curzon, M.P., "The Karun River and the Commercial Geography of South-West Persia."

TUESDAY, MAY 13...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Applied Art Section.) Prof. W. C. Roberts-Austen, F.R.S., "The Use of Alloys in Art Metal-work."

Royal Institution, Albemarle-street, W., 3 p.m. Mr. L. Fagan, "The Art of Engraving." (Lecture II.) "Wood Engraving."

Medical and Chirurgical, 20, Hanover-square, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m.

Photographic, 5a, Pall-mall East, S.W., 8 p.m. Mr. T. R. Dallmeyer, "Reflected Images in Optical Combinations, and their effect on the Brilliancy of the Final Image."

Anthropological, 3, Hanover-square, W., 8½ p.m. 1. Mr. Francis Galton, "A New Instrument for Measuring the Velocity of the Arm or other Limb." 2. Dr. G. W. Leitner, "The Ethnographical Basis of Language, with special reference to the Customs and Language of Hunza." 3. Mr A. L. Lewis, "The Wiltshire Circles."

Colonial Inst., Whitehall-rooms, Whitehall-place S.W., 8 p.m. Colonel John F. Owen, "The Military Defence Forces of the Colonies."

Horticultural, Drill-hall, James-street, Victoria-street, S.W., 1 p.m. 3 p.m., Popular Lecture.

WEDNESDAY, MAY 14...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Dr. J. A. Fleming, "Prof. Elihu Thomson's Electro-magnetic Induction Experiments."

Geological, Burlington-house, W., 8 p.m. 1. Mr. S. S. Buckman, "The so-called Upper-Lias Clay of Down Cliffs." 2. Mr. E. T. Newton, "Some New Mammals from the Red and Northwich Crags." 3. Sir J. W. Dawson, "Burrows and Tracks of Invertebrate Animals, in Palæozoic Rocks, and other Markings." 4. Miss M. I. Gardiner, "Contact-Alteration at New Galloway."

Cymmrodorion, 27, Chancery-lane, W.C., 8 p.m. Mr. D. Emlyn Evans, "The Development of Music from a Historical point of view." (With Illustrations.)

Microscopical, 20, Hanover-square, W., 8 p.m.

Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m.

Patent Agents, 19, Southampton-buildings, W.C., 7½ p.m. 1. Adjourned Discussion on Mr. A. P. Jones' paper, "Trade-Mark Practice;" and on 2. Mr. Morton Daniel's paper, "The Proviso to Section 32 of the Patents Act 1883." 3. Mr. H. Howgrave Graham, "The Progress and Work of the Institute of Patent Agents."

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m. Summer Exhibition of Plants, Flowers, and Fruits.

THURSDAY, MAY 15...SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m. (Foreign and Colonial Section) Mr. C. Washington Eves, "Jamaica and its forthcoming Exhibition." 8 p.m. (Additional Lectures), Mr. Lewis F. Day, "Design applied to Wood-Carving."

Chemical, Burlington-house, W., 8 p.m. 1. Prof. Thorpe and Mr. Barker North, "Diethylphosphorus Acid." 2. Prof. Armstrong and Mr. W. P. Wynne, "The Ten Isomeric Dichloronaphthalenes," and "The action of Chlorine on Naphthalene and Naphthalene Derivations." 3. Prof. Meldola and Mr. Frank Hughes, "A Third Naphthaquinone."

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Lecture by Prof. Hodgetts.

Royal Institution, Albemarle-street, W., 3 p.m. Professor Dewar, "Flames and Explosives." (Lecture II.)

Electrical Engineers, 25, Great George-street, S.W., 8 p.m.

Historical, 11, Chandos-street, W., 8½ p.m.

Numismatic, 22, Albemarle-street, W., 7 p.m.

FRIDAY, MAY 16...United Service Inst., Whitehall-yard, S.W., 3 p.m. Colonel G. B. Hobart, "The Draught of Military Carriages."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Prof. R. Meldola, "The Photographic Image."

Philological, University College, W.C., 8 p.m. Anniversary. Presidential Address by the Rev. Dr. R. Morris.

Quekett Microscopical Club, University College, W.C., 8 p.m.

Physical, Science Schools, South Kensington, S.W., 5 p.m. 1. Lord Rayleigh, "Huygens' Gearing in Illustration of Electric Induction." 2. Prof. S. P. Thompson, "Dr. R. König's Researches on the Physical Basis of Music."

SATURDAY, MAY 17...Royal Institution, Albemarle-street, W., 3 p.m. Dr. C. Waldstein, "Recent Excavations in Greece." (Lecture II.)

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FRIDAY, MAY 16, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

The Society's *conversazione* will take place at the Natural History Museum, Cromwell-road, S.W. (by permission of the Trustees of the British Museum), on Friday, 27th June.

The reception by the Duke of Abercorn (Chairman), and the members of the Council of the Society, will commence at 9.0 p.m.

The bands of the Grenadier Guards and the Scots Guards will perform during the evening.

Each member is entitled to a card for himself (which will not be transferable), and a card for a lady. In addition to this, a limited number of tickets will be sold to members of the Society, or to persons introduced by a member, at the price of 5s. each if purchased before the 14th June. After that date the price will be 7s.; on the 27th June, 10s.

These tickets can now be purchased. They will only be supplied to persons presenting members' vouchers (which can be obtained from the Secretary) or a letter of introduction from a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter a remittance must be enclosed. Each ticket will admit one person, either lady or gentleman.

Light refreshments (tea, coffee, ices, claret cup, &c.) will be supplied.

As the number of tickets which can be issued is limited, early application is desirable.

Proceedings of the Society.

INDIAN SECTION.

Thursday, May 8th, 1890; Major-Gen. Sir Owen Tudor Burne, K.C.S.I., C.I.E., in the chair.

The paper read was—

THE WESTERN FRONTIERS OF CHINA.

By Demetrius C. Boulger.

The mention of the name of China is sufficient to suggest an indefinite number of problems as to its future, whether we place uppermost its own internal development or its relations with other countries. How those problems will work themselves out, and what their solution will be, must remain very much a question of time, and before a final consummation is attained, there will be ample opportunity for individuals to ventilate plausible theories as to what the strangely-constituted community of which we are speaking, and to which the laws of Europe are inapplicable, will become from intercourse with ourselves and other Western nations. I feel, however, compelled to confine myself to the prosaic side of the question, and to only place before you a certain number of facts explanatory of China's action and policy in different important quarters, leaving to you the more pleasing task of evolving your own theories from the historical passages and incidents to which I shall refer.

The particular portion of the very large area of the Chinese empire and its influence to which I would specially invite your attention to-day, is comprehended within the immense line that girdles the dependencies of the Pekin ruler from Manchuria to Tonquin. Much of that circumference, it will be said, lies in the north, and much also in the south, which only shows the difficulty of finding a terse and accurate title for a wide and elastic subject; but all these borders are to the west in the main and practical sense that they are conterminous with two great Western dominions, those of Russia and England. In fact, if we except a very narrow fringe of doubtful territory in the Pamir region, China has now only European neighbours even in the heart of Asia and the interior of Indo-China, and those neighbours are England, Russia, and France. Many natural difficulties still intervene, but these cannot keep out, for any length of time, the traders of those countries who are making steady and increasing efforts to penetrate into China. In two points Russia enjoys a great advantage over her rivals. Not merely is her extent of common frontier greater, and the natural difficulties intervening between Russian and Chinese territory less, but there are also one or two long-established and much-frequented trade routes, of which that *viâ* Kiachta is the best known. In this respect Russia possesses a superior position to ours, and it will be useful to state, *en passant*, that of the 12,000 miles which form the land girdle of China, 6,000 touch Russian territory, 4,800 British territory, and only 400 French, while 800 may be described as doubtful. It will be obvious that the questions arising from time to time along so extensive an area must be affected by local considerations of which we can only possess slight knowledge, but although their number might be indefinitely increased, the most important fall under, comparatively, a few heads, viz.:—Tibet, Burmah, and the Shan States, so far as we are concerned; Manchuria, the Upper Amour, and Turkestan with regard to Russia; and Tonquin in connection with France.

The recent protracted negotiations with China, on the subject of Sikhim, prove that the subject we are about to consider is not one of merely theoretical importance. It is really a matter of much practical moment which will become more evident to the public when, instead of having to restrict or terminate Chinese pretensions in a small Himalayan state, we shall have to define the future boundaries with China in Burmah and the Shan States. To a much-occupied Government like that of India, the prospect of having to negociate with the Chinese on any subject is not a pleasing one. Notwithstanding the telegraph and the presence in Calcutta of a Chinese mission, under the control of Mr. James Hart, an able Englishman in the employment of the Chinese Government, the settlement of the rival claims put forward with regard to Sikhim by the Tibetans and ourselves required more than twelve months. At the same rate of progress, if we may draw a ratio from a comparison of the interests at stake, more than a generation would be necessary to permanently define the Burmese frontier east of the Irrawaddy and the Salween, and, with its recent experience of the dilatoriness of an Oriental Government in the case of Siam the other day, when the Commissioners from Bangkok, notwithstanding the professed and probably sincere desire of the Siamese Government to come to an arrangement, pursued a systematic policy of obstruction, the Government of India may feel some natural apprehension at the strain which would be placed on its patience and forbearance by any prolonged negotiation with China. Still, it cannot be doubted that the question will have to be faced, and now that we are in close touch with the western frontier of China, we can only hope for the early removal of all possible causes of friction, and the exact definition of the rights of the two empires, so that they may be mutually respected.

If the progress of the Sikhim negotiation was wearying, its result can only be termed satisfactory as showing the desire of the Chinese Government to live on good terms with ourselves. We cannot doubt this, because the Chinese have waived much to which they, or rather their *protegés*, the Tibetans, held themselves to be unquestionably entitled. The Rajah of Sikhim is, in the eyes of the Tibetans, one of themselves, and as a Lama, the subordinate of the Dalai Lama of Lhasa. The Pekin Government has little or no interest in a small State so remote from it, and possessing associations that are exclusively Indian, but it has a good deal of interest in keeping the Tibetan hierarchy in good humour. We must, therefore, count it a special act of friendship on the part of China that she has given way to our representations, and acquiesced in a final and formal declaration that Sikhim no longer forms part of Tibet.

The Sikhim question serves to introduce a consideration of China's relations with, and policy in, the important and interesting State of Tibet, with which much of her policy on the western frontier is closely associated. China has been connected with Tibet from a very early period of history, but in the early stages of the relationship Tibet was hostile to China, and in the wars that marked that epoch Tibet was often successful, and figured as the invader of China. It was not until Tibet became a religious community, and ceased to aspire to worldly fame and power by deeds of arms, that Chinese influence became paramount in Tibet, and that the truculent but unwarlike Lamas looked to Pekin for protection against any peril from the Goorkhas or others who might be incited by their own greed, or some lawless act on the part of the Tibetans themselves, to make a descent into the valley of the Sanpu. The more vigorous policy adopted by the Manchu rulers of China under the still reigning dynasty, invested the old claims of the Middle Kingdom with increased force, until at last, under the great Emperor Kanghi and his grandson, Keen Lung, Tibet became the most favoured of China's dependencies. During the last two centuries China has pursued two separate and distinct policies with regard to Tibet, each being dictated by the most pressing necessity of the moment. For the greater portion of the time she has been content with the nominal allegiance of the Tibetans, and the only visible sign of her authority has been the presence of an official called the Amban, who may be compared to the Resident kept by the Indian Government at the courts of the native States, and of a small garrison at two or three of the forts commanding the passes. But on rare occasions the Chinese have thought it necessary to assert their power in Tibet, and to garrison it with a large army. We may devote a little time to the consideration of the circumstances and motives which induced the Chinese Government to vary its action in this quarter.

While the first emperor of the Manchu dynasty, Chuntche, was content to confer on the chief Lama of Lhasa the title of Dalai Lama, by which he and his successors have ever since been known, thus showing the extent and reality of China's influence, his successor, Kanghi, evinced a still stronger interest in the welfare of Tibet. It may be deemed an open question whether Kanghi would have resorted to any active military measures in Tibet if he had not been obliged to do so in consequence of his long struggle in Central Asia with the chiefs of Jungaria and Turkestan, Galdan and Tse Wang Rabdan. During the height of the war with Galdan, when one Chinese army followed another across the Gobi desert, Tibet remained outside the sphere of the contest; but after the overthrow and death of that chief, the Eleuth rulers had to abandon the hope of vanquishing China in the open field, and turned their attention and efforts to another quarter in which they thought China would be less likely to interfere. The situation of affairs in Tibet at the beginning of the 18th century seemed to invite the interference of her neighbours. There had been a recrudescence of the historic rivalry of the Yellow and Red Caps—the representatives of the priestly and military castes—and Tse Wang Rabdan thought it a favourable opportunity to ensure the preponderance of his influence for the future by espousing the side of the Red Caps. After the decisive success of the Yellow Caps (about 1650), which resulted in their expelling their rivals, who took refuge in Bhutan, where their descendants still enjoy a paramount position, the Dalai Lama appointed a new official, named the Tipa, to exercise in his name the military and secular power essential to order, but inconsistent with his sacrosanct character. The holder of this office became a great personage in the State, and after some years it is not surprising to find that this *maire du palais* began to abuse his position. At last the reputed son of the Dalai Lama of the day was appointed to the post, and reluctant to resign an office which he held chiefly from his connection with the head of the Lamas, he managed to suppress the knowledge of his father's death and ruled the State for a period of sixteen years. It was at this stage that the attention of China was forcibly drawn to the position of affairs on the Sanpu, for the Tipa, feeling that Kanghi would declare against him the instant he knew the facts, intrigued with the princes of Jungaria and solicited their military support. When Kanghi was informed of his perfidy, he wrote him a strong letter, stating that he would "direct against him all the troops of Yunnan," and that he would "come himself or send the princes of his Court to wash out in the Tipa's blood the disgrace of his treason." The threats of the Chinese Emperor sufficed to give fresh confidence to the Tipa's enemies, and during the commotion that ensued the Tipa was slain by a military officer named Latsan Khan, who succeeded to his power.

The invitation to the Jungarian prince to interfere in Tibet bore some fruit, for seeing in the overthrow of the Tipa a serious injury to his own reputation and the loss of many material advantages, Tse Wang Rabdan determined to make a bold bid for power in that country. With this object in view he despatched a large army across Kashgaria for the express purpose of invading that country of Tibet, which modern travellers of proved energy and experience, like the late Russian General Prjevalsky, have found so inacccessible, and what is more his General succeeded in accomplishing the main feature of his task by entering Tibet and capturing the capital, Lhasa. This expedition was sent in the year 1709, and it returned to Kuldja or Ili laden with incalculable spoil from the great monasteries of the Sanpu Valley. The Chinese Emperor only learnt of this expedition after it had attained its object and returned in security to the province from which it had set out. He could only provide against its repetition by sending a Manchu garrison to Tibet, and by vigorously prosecuting a war with Tse Wang Rabdan in Central Asia. This was the first occasion of China carrying out the vigorous policy of asserting her power in Tibet, so far as to make it an integral part of her dominion.

On Kanghi's death, which took place a few years after his occupation of Tibet, a policy of greater apathy in this quarter was adopted by his successor, Yung Ching, and even during the greater part of the long reign of Keen Lung the Pekin Government was content to leave Tibet alone, with the result that the Chinese garrison was again reduced to nominal dimensions, and that the only vestige of the Emperor's power was afforded by the resident ambassador. This state of things would have continued indefinitely if unexpected provocation had not been offered the Chinese by a Goorkha invasion of Tibet in the year 1791. The Goorkhas had only asserted their power in Nepaul over the old Newar kings a few years when, tempted by the prospect of booty in the Tibetan lamaseries, they crossed the Himalayas for the purpose of waging war on the Dalai Lama. The Goorkhas easily overcame the slight resistance offered by the Tibetans, but as the Chinese had received some warning of their intended attack, they only succeeded in taking and pillaging the town of Shigatze and the lamasery of Teshu Lumbo, before they found it prudent to retreat on the rumoured approach of a large Chinese army. The Goorkhas delayed their retreat until the last moment, and as their march was hampered by the quantity of their baggage and spoil, the Chinese succeeded in coming up with them in the Kirong Pass of the Himalaya. A battle was fought at Tengri Maidan, when the Goorkhas were vanquished, and in several pitched battles the fortune of war declared itself unequivocally in favour of the Celestials. The final battle of the war was fought at Nayakot, and after the overthrow of their last army, the Goorkhas only succeeded in averting the occupation of their capital by signing an ignominious peace which made Nepaul a tributary State of China. *En passant*, I would observe that this campaign has always seemed to me the safest and easiest test of the efficiency to which a Chinese army could attain. People generally, and many military experts, deride the warlike prowess of the Chinese. It seems to me impossible to do so after a careful consideration of this campaign, and a comparison of its triumphant course with our own arduous operations in Nepaul twenty-five years later, when it took two severe campaigns for us to gain a far less decisive victory over the same opponents. The annals of our own Indian army prove conclusively that no Asiatic race possesses superior military qualities to the Goorkha.

To this striking and brilliant service the Chinese were indebted for the greatly increased hold they have possessed on Tibet during the last century. The Tibetans were bound to entertain a grateful feeling towards the Power that had rendered them such timely aid and effectual protection, and that had inflicted so salutary a lesson on a neighbour who would otherwise have proved a constant nuisance and peril. The resident Chinese garrison was considerably increased, and the Amban was instructed to take a more active part in the administration, but, indeed, these measures were unnecessary, as the Tibetans had no other thought than to make themselves as agreeable as possible to their protectors. During the hundred years that have elapsed since those events, China has gradually relaxed her hold on Tibet, so far as active participation in the military and civil government of the country is concerned; but her paramount authority has never been questioned, and in proof of this it may be mentioned that the quinquennial tribute-bearing mission from Khatmandu still passes through Tibet to Pekin. The time has now arrived for a fresh exhibition of Chinese authority in Tibet. I think we should be prepared to see at an early date an increase in the Chinese garrison of Tibet, and the Pekin Government will be impelled to take this step both by the experience acquired during the recent Sikhim negotiations, and by apprehensions at the continual efforts of the Russians to gain an entrance into this remote and little known province. The expedition of Colonel Pevtsoff, now roaming on the borders of Tibet, will recall the danger that once beset Tibet and the Chinese position in that country from the Eleuth princes, whose base was also on the banks of the Ili. We can have no objection to some stronger and more amenable authority being established at the frontier posts of Tibet than the rabble following of the Lamas, who, from ignorance or religious zeal, did not know their own impotence.

The policy of China on her western frontiers was, so far as Tibet and Turkestan were concerned, closely connected. She garrisoned Tibet in order to keep out the Eleuths, and under the Emperor Keen Lung, she conquered Turkestan so that the Eleuths might be rendered incapable of invading Tibet, and by this means she carried her borders up to great and almost impassable mountain barriers in the Pamir and the Himalaya. She was induced to do this, not by any greed of territory, nor from any wanton spirit of aggression. The lawless and unprovoked proceedings of the chiefs and clans of Turkestan and Jungaria, who would have been emboldened by the slightest success to undertake the invasion of China proper, in imitation of the Mongols and other desert conquerors of the Middle Kingdom, including the Manchus themselves, compelled the Chinese Emperor, in self-defence, to wage war upon them, and experience showed that no reverses east of Turfan sufficed to curb their turbulence, or to deprive raids in the direction of China of the attractiveness such an enterprise possessed in the eyes of the Central Asian nomads, who had nothing to lose. It was with the greatest reluctance that the policy of annexation was at last finally adopted by the Emperor Keen Lung, as the only remedy that ensured the permanent cessation of a constantly recurring annoyance and danger. When that great ruler annexed the regions north and south of the Tian Shan range, which are now known under the names of Kuldja and Kashgaria, and placed a garrison in Tibet, he attained a perfect solution of the difficult problem which had beset Chinese rulers for centuries, viz., security on the western frontier. It may be said that even his solution did not endure, and that under his incapable successors his conquests were lost and with them also the fruits of his policy. But, on the other hand, it can be argued that the Chinese have thought it wise to make the effort to recover what they had lost, and this they accomplished ten years ago. The problem they have now to face is whether they can maintain their hold on their remote Central Asian provinces without some improved means of communicating with them. It seems to me that unless China lays down a railway, not necessarily to Kashgar, but to the borders of her north-west province of Kansuh, it will be impossible for her to hold her position in Central Asia against Russia whenever that Power feels inclined to assail it. Before long Russia will have extended her railway to Khodjent and Tashkent, and the movement of troops against the Chinese in Kuldja and Kashgar would thus be greatly simplified. There is every probability that the opinion formed not only by General Prjevalsky, but by all the English officers who have visited Eastern Turkestan, that the Russians could crush the Chinese in Central Asia before the Pekin Government could send adequate reinforcements, would be vindicated by the result. We can therefore only come to the conclusion that the policy of China in absorbing the region from the Gobi to the Pamir, which in the past gave her security against invasion by the Mahommedan and other tribes of Central Asia, has in the present day brought her face to face with a danger which she seems to only imperfectly realise, and towards meeting which she has done during the last ten years very much less than she ought.

In order that too pessimistic a view may not be taken of China's position in Central Asia *vis-à-vis* with Russia, I would call your attention very briefly to another part of what I have ventured to call the western frontiers of China. I refer to the valley of the Lower Amour, and China's position with regard to maritime Manchuria and its well-known naval port of Vladivostock. In this direction China has not been idle, and European visitors to this region are almost as unanimous in their opinion of the military strength of the Chinese position therein as they hold an adverse view on the point of China's capacity to resist Russia in Central Asia at the present time. The only point I wish you to infer from this is that, weak as China may be in Turkestan, she possesses the power of retaliation elsewhere; and if the Chinese fleet could successfully cope with the Russian Pacific squadron, there is every reason to suppose that, crushing as China's defeat in Kashgaria might be, that of Russia in Manchuria would not be less so. It would, therefore, be somewhat misleading to say that, because Russia could overthrow China in Central Asia, there is imminent risk of a hostile collision between those two empires. The situation in Manchuria is calculated to inspire the Russian military authorities with caution; and when China connects even Moukden, not to speak of Kirin and Tsitsihar, by railroad with Pekin, she will have taken the only step still necessary to establish her security, and probably her superiority as well, in north-east Asia.

We must now turn to the more southern portion of China's western frontier, where for the greater distance we are her only neighbour, and where for a shorter space she is also contiguous with France. As China has never been exposed to any serious danger from this quarter, or felt any great peril of invasion from the south, it is not surprising to find that she has no historical policy in this direction, similar to that she possessed in Central Asia from a much earlier time than I have liked to call your attention to. It is true that on more than one occasion the Burmese have crossed the Yunnan frontier, and history also shows that there have been Chinese invasions of Burmah; but these have been merely passing incidents in the life of a great empire. The hostility of the Burmese never attained the formidable character of that of the inhabitants of Central Asia, and the great campaign of 1768, when the Burmese were vanquished, and compelled to sign a treaty binding them to pay tribute to the Chinese Emperor, sufficed to place the relations of the two States on what has proved to be a durable basis. Beyond regarding the position of affairs in this quarter with a considerable amount of complacency, from the fact that one of the proudest potentates of Asia had ranked himself among the tributaries of the Son of Heaven, it does not seem that the Chinese had any fixed policy towards Burmah. They were quite content to leave matters as they were, especially when they found that even the formidable Mahomedan revolt in Yunnan did not impel the Burmese to take advantage of that occurrence to encroach on Chinese territory, as would infallibly have been the case if they had been Khokandians or any of the other Central Asian peoples, who always endeavoured to profit by the embarrassments of the Chinese. The first disturbing influence was introduced by our conquest of Upper Burmah, for the Chinese perceived that instead of an easy-going and weak neighbour like the Kings of Ava and Mandalay, they would henceforth have to do with a somewhat exacting and not less powerful neighbour in the Indian Government. Regret at the change, as well as the desire to keep up old formalities, may have explained the tenacity with which the Chinese clung to their rights of suzerainty over Burmah; although that might have been explained by the somewhat light manner in which many authorities sought to treat China's claim to demand tribute from Burmah as a pretension that had no basis in fact. Negotiations of a very delicate nature ensued from the time of our occupation of Burmah until August, 1886, when, by the efforts of Lords Salisbury and Rosebery, an amicable convention was signed, by the terms of which China's pretensions were admitted, and an arrangement was made for the continued despatch of the tribute-bearing mission to Pekin. I may be permitted to call your attention to the fact that during the whole of this delicate negotiation, the distinguished officer who honours me by presiding this evening was the political secretary at the India-office, and took consequently an important part in arranging in an amicable and honourable manner the first difficulty that presented itself when England and China became neighbours beyond the Irrawaddy.

We can only hope that the difficulties which will present themselves in regard to the delimitation of the ill-defined frontier between Burmah and Yunnan will be overcome with equal success. Up to the present no steps have been taken towards appointing a frontier commission, and perhaps it was wise to let the more important matter stand over until we had come to an agreement with the Siamese in the Shan States. Unfortunately no success can be chronicled with regard to the efforts made during the past six months to come to an arrangement with the Siamese, and our chief representative, Mr. Ney Elias (than whom no one knows Eastern countries and peoples better) has returned to Simla *re infecta*. He and his colleagues have collected a great deal of valuable information, and it really looks as if the only practical outcome of their exertions will be for us to trace what seems to be a fair and workable boundary through the Shan States, and notify the Court of Bangkok that we shall require it to be respected. Our experience in this quarter will suggest the advisability of proceeding with considerable deliberation before we commence, in conjunction with China, the delimitation of our common frontier. It would not be surprising if many years were to elapse before an Anglo-Chinese frontier commission met to discuss the question at all. The Chinese certainly are not over anxious to enter upon a formal arrangement as to boundaries, which would be the preliminary to increased intercourse, and to the opening of distinct trade routes between Burmah and Yunnan. Nor are we perhaps more anxious to begin the matter than the Chinese, for we have so much to do in Burmah and the Shan States with regard to the improvement of our communications and the construction of railways, that we may well hope to be in a better position to come to a satisfactory arrangement with China some years hence, when more of the necessary work for the thorough administration of Burmah has been accomplished. There is another reason why a little delay may be advisable and conducive to the interests of the two countries, and it is this—

although there can be no question that England is more sympathetic at heart with China, and a truer friend of hers, she might be a more troublesome and exacting neighbour than either France or Russia. To support this view it is only necessary to refer to the acts of brigandage committed by the Black Flags in the Bacninh district since peace was proclaimed between France and China, and to the frequent raids of Chinese Kirghiz on the Russian frontier between Semipalatinsk and Kuldja. If those acts had been committed on the Indian frontier, it is perfectly clear that they would not have been treated with the same lenity, and the Government of India would have felt bound to demand as ample and as prompt reparation from the Chinese Government for the acts of its subjects as it would do in the case of offending border tribes, such as the Afridis or the Akhas. For such reasons as this, it does not at all follow that because there is, practically speaking, close identity of interest between England and China we should make the most agreeable neighbours on a frontier, where China has been content to exercise an almost nominal authority, and to leave the clans very much to follow their own inclinations. In the interests of both countries, therefore, it may be well to wait awhile before attempting to place on a regular and final basis the exact delineation of the respective authorities of England and China in South-East Asia. The natural progress of events will probably produce a simple and satisfactory solution of all the difficulties connected with this subject.

Summing up the whole question, or rather the number of questions connected with the western frontiers of China, we find that the chief policy pursued by the Chinese executive has been to drive to as great a distance from the capital as possible the hostile forces which might injure the Chinese nation or break up the empire. That policy was crowned with success when the limits of the empire were carried to the Amour, the Pamir, and the Himalaya, while in the south-west there never was any need to encroach beyond the mountains of Yunnan. Under old conditions, when China had only to deal with Asiatics, and when Russia was weak and only existed on sufferance in Asia, that policy was both wise and successful. China obtained in every quarter a strong natural frontier, for the defence of which her military resources amply sufficed without placing any too severe a strain on the resources of the central authorities. But within the last thirty years a marked change has taken place. Instead of attaining greater security by marching into Central Asia, and renewing the conquests of Kanghi and Keen Lung, China has really brought nearer to her the great national danger from Russia. It is true that the reconquest of Turkestan was effected for the express purpose of putting an end to what seemed an imminent peril from a recrudescence of Mahomedan fanaticism in the north-west, and that so far as that object went, its success was complete. But the success carried this penalty with it, that it left a considerable Chinese army virtually cut off from communication with its base, and exposed on the outbreak of war with Russia to the risk of being annihilated before assistance could reach it. China has done nothing towards repairing that weak point in her armour, and although the greatest empire must be prepared at an hour of need to sacrifice a garrison, the success of a policy must be deemed qualified when it starts upon a catastrophe so clearly perceptible, and against which no precaution has been taken. The *raison d'être* of Chinese policy on her western frontiers has been not merely to ward off dangers, but to save herself the trouble of being annoyed periodically by the depredations and hostile designs of the Central Asian tribes. In the past the policy of annexation was crowned with success; but in order that it should be equally successful under modern conditions, it is necessary that China should not delay in providing railway communication between Pekin and Manchuria on the one side, and Turkestan on the other; and that she should, in good time, place a strong garrison in Tibet. Unless China is prepared to make good her position on the extended frontier that she has taken up, it would better for her to draw in her boundaries, to evacuate Central Asia, and to confine herself to the defence of her nineteen provinces and Manchuria. This prudential retrenchment is not likely to be made by a State so much wedded to the past as China, and, therefore, we can only expect that Chinese statesmen will do their best to hold their own by preparing for a vigorous offensive where they are strong, as a counterblow to Russia's success where they are weak. It would be fortunate for the peace of the world if these efforts were to lead Russia to think that war with China was "a game not worth the candle." The question, however, that the Chinese have very seriously to consider is whether their policy on the western frontiers which answered in the past is quite applicable to the present day. Instead of weak neighbours they have now to deal with two strong and exacting empires like England and Russia. They cannot permanently close their doors to the traders of those Empires, and they must realise that now-a-days trade is impossible without railways. Before many years we shall be knocking at the gates of Yunnan, and Russia at those of Mongolia, and China will have to listen to the summons and open her barriers. For that concession China should be prepared, and if she is wisely advised she will even anticipate the day of surrender, thus showing that she has not forgotten her old political knowledge, and that as she knew how to lay down an astute policy for guiding her relations on her western frontier in the glorious past of Manchu and Chinese history, so has she now risen superior to prejudice, and been able to modify it, or to adopt a new one, suited to the exigencies of the time. To do this she has not merely to show a bold front to her enemies, but to reciprocate, which is more difficult for her, and less in accord with her traditions, in a genuine and hearty manner the good wishes, and to comply with the reasonable requests of her friends.

DISCUSSION.

Mr. MICHELL said he did not see any necessity for delaying an attempt to secure a frontier with China until our position in Burmah had become stronger. If our position in Burmah promised to be good, a stitch in time would save nine, and it would be well to at once begin an effort to establish that authority and influence in Pekin which in similar cases were greatly delayed until someone else was before us, as in the case of Persia, where we allowed the ground to be cut from under our feet by Russia. He did not see that China had experienced any overwhelming difficulties in Eastern Turkestan; they had always managed to master easily the difficulties they met with there, as witness their recovery several times of the province of Ili and Jettishahr, where they had to contend with enormous difficulties, but they recovered those provinces from vast millions of fanatic people led by vigorous chiefs, who were not mere adventurers like Yakoob Beg, but founders of the sacred dynasty. He did not think there was now any representative of the royal dynasty in Eastern Turkestan, and it was not likely that another Yakoob Beg would arise to oppose them. It would be easy therefore to hold the country against all comers, Russia included. The retrocession of Kuldja to the Chinese was a most remarkable fact, especially after the declarations made by Russia that she intended to retain every inch of territory she had acquired, and showed that the Russians stood in awe of their neighbours along the whole line of their extended frontier. The Chinese were a peace-loving people, who would not declare war except under great provocation, but they evidently were able to put great pressure upon Russia. It would therefore be waste of time to recommend our own friendship to China on the ground of any fears she might have of Russia on her northern frontier. We should rest our case rather on our position in Burmah, and we ought to begin negotiations at once.

Mr. C. W. MITCHIL, as one who had spent twelve years in China, could bear testimony to their comparatively good management of their own country. There was a system of passports, and he had travelled about with one a good deal, but scarcely ever had occasion to use it. The Chinese had a beautiful saying from Mencius to this effect:—" Benevolence (or humanity) is man's peaceful abode; righteousness is man's true path." Every schoolboy had to commit that to memory, and though there was a good deal of the parrot system about their education, those who remained a good while at school had these things expounded, and he believed that such sayings as this had a good effect on the national mind, and it would be as well if some Western countries adopted the same principles. But whilst the Chinese were peaceful, they were becoming more and more aware of the importance of being well equipped in case of attack, and he had just received a letter from a friend in Hanyang, in Central China, informing him that the new viceroy of the province had discarded the bow in the military examinations, and had given the students ninety days in which to learn the use of the rifle. Those who had been some years in China, had been amused to find that the military students, who were hereafter to become officials, had still to practise with the bow and arrow on foot and on horseback, though the regular soldiers had been for some years trained in the use of the rifle; but the bow was now being discarded altogether. He had been much interested in this paper, and he trusted that in any future communications with China we should act in the most straightforward and honourable way. At present England was much respected. Up to the time of the French war, Englishmen and Frenchmen were all classed together as foreigners, but they then discovered there were foreigners and foreigners, and he had found it more than once an advantage to be able to say he was not a Frenchman. The question of the tribute from Burmah was of importance, because the people of China had a notion that England paid tribute to China, and when they were told that though England was a very small country, she had immense countries, such as Australia, larger than their eighteen provinces, and India, with a population of 250,000,000, as tributary kingdoms, they opened their eyes in astonishment. In a recent sheet almanac which was printed and circulated at Hankow, was inserted a paragraph showing the area of the different great empires, in which Great Britain came first, next Russia, and then China, and he thought the dissemination of such information was very useful.

Mr. W. MARTIN WOOD said this was a subject on which he had long felt considerable interest. He thought one of Mr. Boulger's remarks, that the Chinese frontier was 12,000 miles altogether, of which 4,800 miles touched British territory, required to be somewhat qualified. It did not follow because the intervening powers or tribes between the Chinese territory proper and our own were not recognised in European diplomacy, that therefore the Chinese territory extended up to ours; there was a certain no man's land between, and this was none the less so, though China was able to send garrisons to Tibet. In speaking of Sikhim, it should be understood that half of it was of a different tenure from the other half, with which the Chinese were concerned. Again, it was said that one of the early Chinese expeditions obtained "incalculable" spoil from the banks of the Sanpu, which he thought was rather too strong a statement; at any rate, some estimate might be given. The amazing power exercised by the Chinese at such an immense distance from Pekin was one of the most striking facts in the history of the world. In our own time we had seen in Kashgaria their power overturned for a time, and a Mussulman dynasty arose, so complete that it sent envoys to Europe. He himself had seen the envoy Yakub Beg, who was a very capable man. He remembered asking him if he could point out the part of Asia from which the Usbegs originally came; and though Yakub could not read Captain Trench's map, which he showed him, he asked where Yarkund was, then on its being pointed out, he traced out where he considered was the birthplace of the Usbegs, beyond Tian-shan range far to the north-east That would serve to indicate the intelligence of these people, and yet the new State, compact and efficient as it seemed, was utterly swept away by the Chinese. The re-cession of Kuldjah was another most remarkable instance of their power. Again, in the south-west they saw part of that same recrudescence which Mr. Boulger referred to, which swept through the whole of Jungaria; then the little kingdom of the Panthays in Yunnan was set up, which also sent envoys to Europe. But before they could get back again the whole State was wiped out. He did not know that there was any moral to be drawn, but it was a most remarkable fact, this tenacious, overmastering power of the Chinese. He agreed with Mr. Boulger that they would be strong enough to resist the Russian forces, but that they could not do so without better means of communication. It was a consideration of this, probably, which induced Gordon to advise them to remove the capital further away from the sea, to Nankin. This paper, in various ways, brought before one the inconvenience and difficulty forced upon us by our coming directly in contact with the Chinese frontier; and the author seemed to favour the policy of being very patient, imitating the policy of the Chinese themselves, and putting off the evil day of drawing a definite line as long as possible. Mr. Michell expressed a different view, and he would not venture to judge between them; but if the former view were correct, why did we not only upset Theebaw but abolish the native dynasty of Burmah, and make ourselves the immediate neighbours and possible antagonists of the Chinese in that remote region, where they would have the advantage in every way? Some people had a very imperfect sympathy with the Mongolian character, but there were others who appreciated them highly, not only for their intellectual capacity, which was very great of its kind, but for their moral qualities. He feared that, as in other cases, there was often a wide gap between their faith, theory, or maxims, and their actual conduct; but, at the same time, there was much to admire about the Chinese, especially their non-aggressive character, though they were determined to hold their own. If we could convince them we wanted nothing more than was right and fair, we should probably get on with them much better than with the Muscovites.

Mr. C. E. D. BLACK thought it was very important to come to some understanding with China as to the boundary of Upper Burmah. One could not disguise the fact that an undefined boundary had often been the cause of misunderstanding, and the sooner it was settled the better would it be for both parties. Mr. Boulger said we should soon be knocking at the gates of Yunnan; but it was rather extraordinary, considering how much was said twenty years ago about making railways into south-west China, that these projects seemed to have so entirely died out. He remembered Captain Sprye's scheme and various others being brought forward, but now that the annexation of Upper Burma had brought us nearer than ever to South-West China, it was strange that one did not hear much about such projects. He should like to know what people thought of uniting the Indian railways with the Burmese, which, if accomplished, would no doubt lead to a great increase of trade.

Mr. W. S. SETON-KARR congratulated Mr. Boulger on the admirable historical sketch he had given, and especially on the calm tone with which he had treated the political questions which his researches had naturally forced upon him. He might make one slight criticism on what the reader of the paper said when comparing the English warlike operations against the Goorkhas with those of the Chinese, which he described as so successful. His own recollection of the Nepaul war was that our losses took place in taking walled forts, and in the end we certainly conquered and obtained a valuable province; but in the case of the Chinese one battle took place in a large open plain, when the Goorkhas were retreating in the face of a numerous army, and were probably more or less demoralised. Something was said about the diplomacy of China and Russia; he had never been in either country, but from what he had heard and read, he would rather treat with the Chinese diplomatists than Russians, especially with the affair of Pendjeh in his recollection. Mr. Boulger said that in a few years we should be knocking at the gates of Yunnan. He hoped we should knock with the moral pocket-handkerchief in our hands, and not with the cannon ball. The time was coming when China could no longer remain exclusively apart, but would have to contribute to the world's debate. We should facilitate this by all the means in our power, and if China would begin by laying down railways to our frontier, it would be time to consider whether it was right to pledge the English or Indian Exchequer for their extension.

The CHAIRMAN said—I rise chiefly with the object of asking you to join me in expressing the acknowledgments of this Society for the trouble which Mr. Boulger has taken in bringing before us so much valuable information as to China and her western frontiers. Speaking generally, there can be no doubt in the minds of those who have watched the relations between this country and China during the present century that there has been a great deal of suspicion and coldness on both sides, and a certain dislike to the idea of the boundaries of the two empires being in any way conterminous. But it is evident that a beneficial change has now taken place in this respect. There has recently been, in short, an increase of confidence and cordiality which cannot but be advantageous to both sides, more especially as, notwithstanding efforts to the contrary, some 4,800 miles of the land-girdle of China, as we have been reminded by Mr. Boulger, now touch British Indian territory. For my own part, I am glad of this "march of the frontiers," feeling that the more we see of each other the better friends we are likely to become, inasmuch as while China is content to safeguard her rights and to remain as she is, we have no real desire to encroach on our neighbours; and we have only done so, as in the case of Burmah, when compelled, after years of patient endurance, to put a stop to a state of things which had become dangerous and intolerable. It is evident, as matters stand, that while we are learning to move with caution combined with perfect openness in regard to the external relations of India, the Chinese Government are getting rid by degrees of that suspicion of our aims and objects that has made them slow and obstinate in past intercourse and negotiation. When once this mutual feeling of trust and goodwill is firmly cemented, there can be no further doubt of the advantage to both empires of facility of intercourse and cordiality of relations. I venture to share Mr. Boulger's satisfaction that the Sikhim negotiations have been brought to a final termination. There never was any real doubt of our entire right over the suzerainty of Sikhim, but the recent Convention officially stamps this fact, and its conclusion should be regarded by all who are interested in the Indo-China question, not only as an evidence of the good will of the Chinese Government towards us, but as affording an opportunity to ourselves to assure China that we have no desire or intention to make Sikhim a "stalking horse" to Thibet; preferring, as Mr. Boulger had pointed out, the strong hand of China over that country, if she will but exercise it, in preference to the present rabble following and obstructionary tactics of the Llamas. We have, in past years, been anxious to establish trade relations between India and Thibet, and China has formally engaged to aid us in so doing; but after all, the value of that trade has been somewhat over-estimated, and we may all be confident that the Indian Government will take no steps in regard to it that can be at all objectionable to China. While on this subject, our thoughts wander back to the late Marquis Tseng and to Mr. Coleman Macaulay, both of whom were much interested, some few years ago, in this question. And we cannot but pay a passing tribute of regard to the memory of one of China's best and most far-seeing of statesmen, and to that also of a most able and devoted servant of the Indian Government. We deplore the loss to the world of these lamented men and we honour their memories. Mr. Boulger has referred in the course of his remarks to the convention between this country and China, relative to Burmah and Tibet, which was signed on the 24th of July, 1886, and to the possible delimitation of the frontier between Burmah and China by a special Boundary Commission. I agree with him in thinking that the natural progress of events will probably produce a simple and satisfactory solution of all the difficulties connected with this subject. The disturbed state of Burmah has hitherto done much to arrest any action in this direction, but when the time arrives for such action, I think we need have no fear of any complications arising in regard to it. I venture to agree in the general concluding remarks of the reader of the paper. China must no doubt wake up on the question of the general protection of her empire from active neighbours and enemies. But so far as England is concerned, I think that the Chinese Government need not trouble themselves much about us, except to second our efforts for increasing the facilities of trade and commerce between the two empires, by the construction of railways and the improvement of internal communications. With two such men as Sir John Walsham at Pekin, and Sir Halliday

Macartney in London, we need not fear that this matter will be forgotten, or that every encouragement will not be given, as time goes on, to facilitate trade and intercourse between China and India.

Mr. Hyde Clarke writes:—So many gentlemen were present connected with India and China that I deferred speaking, although I should have liked to give in a tribute to Mr. Boulger. The whole subject of our relations with China is of the greatest material and commercial interest, and has consequently much occupied us in the Indian Section. On one point it appeared to me Mr. Boulger has laid himself open to misconception, and that is the way in which he has referred to the Chinese reconquest of Yarkand and Kashgar. He intimated that they ought never to have taken that step, as they are now exposed far from their base to a powerful enemy. At the period of that event China did not know that Russia was to make so great an advance in Turkestan. China had been in danger, too, of our aiding Yakoob Beg, as many of us then wished, and she had reason enough for jealousy of England. It was, however, a matter of great moment for the prestige of China to recover her place in Turkestan, and undoubtedly that conquest did restore her prestige in Turkestan and also in Europe. To China it must be always a matter of importance to keep up her influence among the Altaic races, and, notwithstanding her repression of the Mussulmans, she stands better with them and the Altaic races than does Russia. The latter, which most successfully governed alien races, has abandoned her old policy of preserving their institutions, and has adopted russification. One hundred years ago, in consequence of the American war, the prestige of England in Europe was at low ebb, and among the measures adopted by William Pitt to restore it was his firm resistance to the encroachments of the Spaniards at Nootka Sound, on the American Continent. By his firmness in October, 1790, the treaty of Madrid was signed, by which Spain gave satisfaction, and it is not unworthy of remark that in this hundredth anniversary, which we hope to celebrate, we profit by the possession of British Colombia. So too, similarly, so far as China is concerned, the reconquest of Kashgar has rehabilitated her. If Mr. Boulger's policy is carried into effect, and railway communication is provided, he has less reason to fear for Turkestan. In reference to the power of China to contend with Russia, we are apt to undervalue her chances ethnologically. We lay it down as a contest of Mongolians with Aryans, having chosen to classify the Russian populations as Aryan and Indo-European, on account of the ruling language. How far this can fully be done is very doubtful. The general evidence of men of science is unfavourable to the allotment of an Aryan status to them, but rather to regard them as largely Ugrian in origin. When our kinsmen, the Warings or Varini, established the Russia empire, they evidently looked on the population as chiefly Ugrian, and so they are described by the earliest chronicler, Nestor. The spread of the Slavonian language subsequently took place among the Ugrian populations. These are incidents to be carefully taken into account in comparing the characteristics of the two great empires.

Mr. George Crawshay writes:—The paper is full of valuable information, and contains important suggestions which will, I trust, receive due attention at Pekin; but what has chiefly impressed me is the just appreciation on the part of the Chairman, the reader of the paper, and every one of the speakers, of the greatness of China. I gather from this that the opinion which was so prevalent at the time when we were doing them wrong that the Chinese were "barbarians," is now finally dispelled. This is a delusion which I never shared, but which was, at the time I refer to, nearly universal in this country. The wise policy of the Chinese Government in sending to England representatives, whose presence among us we found to be so great an advantage, has contributed greatly to this happy result; but study alone ought to be sufficient to convince us that in regulating our intercourse with China we have to do with an empire more majestic than any in existence. Of all the great empires of antiquity, the Chinese Empire is the only one that survives; nor is there any sign that it will not continue to exist as long as any of the more recently organised communities that rule the habitable world. Amidst all vicissitudes China has clung fast to the principle of reverence for parental authority, and as there is no sign of any weakening of this principle in China, so I venture to affirm there is no sign of her decay. Nevertheless it cannot be denied that, as Mr. Boulger has shown, China is exposed to danger from without, and that to meet that danger, and, at any rate, prevent a period of trouble and anxiety, and possibly of loss, she had better at once take measures to improve her internal communications, so as to be able to meet her enemy in the gate. It occurred to me, in listening to Mr. Boulger, that he was addressing his observations rather to the Chinese Government than to an English audience. I venture to say to the Chinese Government take to heart what your friend Mr. Boulger has said.

TWENTY-FIRST ORDINARY MEETING.

Wednesday, May 14th, 1890; A. B. W. Kennedy, F.R.S., Member of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Eaton, Edmund Octavius, B.A., B.Sc., 27, Martin's-lane, Cannon-street, E.C.

Posno, Charles Jaques, 19, Finsbury-circus, E.C., and The Woodlands, Grove-park, Lee, S.E.
Simpson, John, Wirksworth, Derbyshire.
Turner, Sir Charles, K.C.I.E., 29, Palace-gate, Kensington, W.
Tyler, Charles, Elberton, New West-end, Finchley New-road, N.W.
Wünsch, Edward A., Carharrack, Scorrier, Cornwall, and Glasgow.

The following candidates were balloted for and duly elected members of the Society:—

Benest, Edward Everett, 38, Glebe-road, Bromley, Kent.
ry, Albert, 8, Cambridge-park, Redland, Bristol.
Thomason, William, Messrs. Doulton and Co., St. Helens, Lancashire.
Thomlinson, William, Seaton Carew Iron Company, West Hartlepool.
Vaughan, R. Wyndham, 64, Broad-street-avenue, E.C.

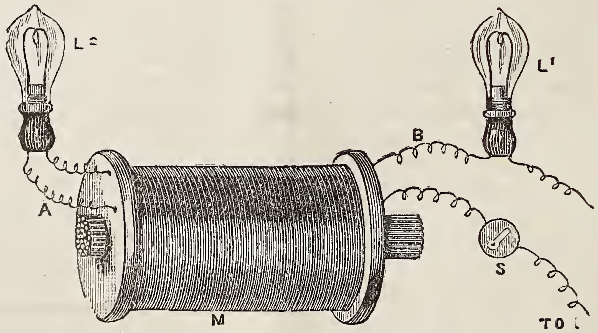
The paper read was—

PROF. ELIHU THOMSON'S ELECTRO-MAGNETIC INDUCTION EXPERIMENTS.

By J. A. Fleming, M.A., D.Sc., M.I.E.E.,
Professor of Electrical Engineering in University College, London.

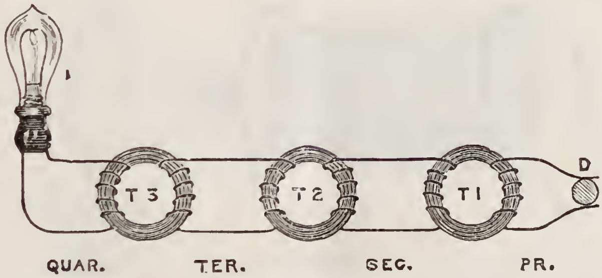
I. In the Paris Exhibition of 1889, and in the United States Court, many present will, perhaps, recollect to have seen a collection of electrical apparatus, contributed by Prof. Elihu Thomson as his private exhibit. These pieces of experimental apparatus constituted the appliances for illustrating some highly remarkable and interesting facts in electro-magnetic induction. It is more than probable that very many persons interested in electrical discovery either did not find, or did not happen to see in action, these instruments, or perhaps had not the opportunity to see them at all. By the kindness of Prof. Elihu Thomson, to whom I am indebted for the loan of the apparatus, it is in my power to repeat some of these experiments before you to-night; and my obligations are likewise especially due to Mr. Ernst Thurnauer, the engineer of the European Thomson-Houston Electric Light Company, for affording me his valuable aid in bringing them before you, and to Mr. Garfield of the Thomson Electric Welding Company, for assistance in preparing the experiments. A few introductory remarks will be essential, in order that I may carry the whole of my audience with me in subsequent explanations; and these remarks will refer to that which is so very familiar a subject to every electrician, viz., the mutual induction of electric circuits. Before me lies a very large bobbin, or spool, wound over with two insulated copper wires. These wires were wound on the spool together, and for convenience sake we will distinguish them by calling them A and B (Fig. 1). Bear in mind that the wires or circuits are insulated from each other throughout their entire length, but lie closely adjacent on the bobbin. I can at pleasure insert a large bundle of soft iron wires tied up together into the hollow split brass tube which forms the body or the spool. The ends of one wire, say A, are connected to the terminals of a glow lamp, and I can pass or interrupt an electric current which traverses the other circuit, B, and a second glow lamp in series with it. You will note at once what happens when I start or stop the electric current in the circuit B. The lamp connected to circuit A flashes up momentarily at the instant when the current begins to flow in circuit B, and also when it ceases to flow; but whilst the current flows steadily in the circuit B and illuminates the lamp in series with it, the lamp in series with circuit A is not illuminated at all. We have here a lecture experiment illustrating

Fig. 1.



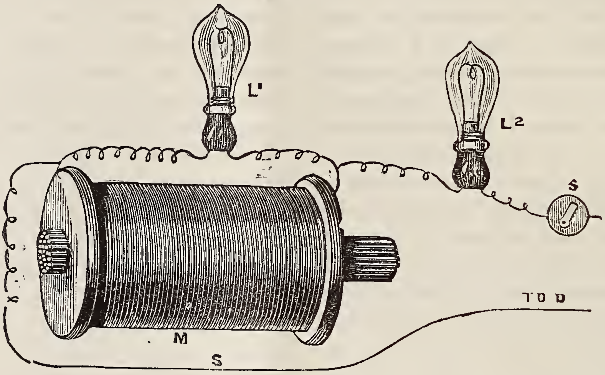
the familiar classical discovery of Faraday of the mutual induction of two electric circuits, viz., that the starting or stopping of an electric current in one circuit induces at the instant of commencement or cessation a brief secondary current in another closed adjacent circuit. I shall not take up time by dwelling on the historical details of this fundamental fact. You know them well. If instead of starting and stopping a continuously flowing electric current through the circuit B, and observing at each "make" or "break" a brief secondary current in circuit A, we supply the circuit B with an alternating electric current, one of which the direction is rapidly reversed many times in a second, and connect as before a glow lamp in series with circuit A, we find that this lamp glows continuously whilst the alternating current flows in circuit B. This also is familiar to us all. If in our first experiment we had employed, as a current detector in the secondary circuit, not an incandescent lamp, but some kind of galvanometer capable of indicating the direction of the induced electric current, we could easily have established for ourselves the fact that at the instant when the continuous electric current begins to flow in the circuit B, it generates an oppositely directed induced secondary current in the circuit A, which is merely a transient current. At the instant when the continuous current is interrupted in circuit B, it gives rise to a similarly directed transient induced electric current in the circuit A. The momentary currents in A are called the *inverse* and *direct* secondary currents, induced by the commencement or cessation of the continuous primary current in circuit B. If the primary current is rapidly reversed, as in the case of an alternating current, then the secondary current consists likewise of a rapid succession of currents alternating in direction. In most of our experiments this evening we shall employ an alternating current, having a "frequency" of 90 per second—that is to say, changed in direction in the circuit 180 times in a second, and provided for us by the kindness of the London Electric Supply Company. If such an alternating current traverses a primary circuit, it induces a secondary alternating current of the same frequency in an adjacent secondary circuit, and this secondary periodic current may be made to induce in another circuit a tertiary current of like frequency, and this, again, a quaternary current, and so on; these successive orders of induced currents being, as it were, the children, grandchildren, and great-grandchildren of the primary parent current to which they owe their birth. (Fig. 2)

Fig 2.



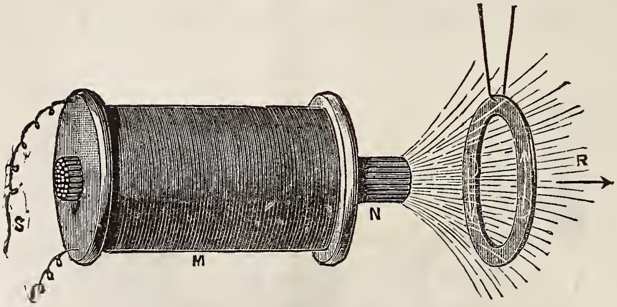
The same large spool of insulated wire will provide us with the means of illustrating another important fact. I join up the two wires, A and B, into one length, so as to form one continuous bobbin of wire, and connect this great spiral of wire with a couple of glow-lamps, one being in series with the wire spiral, and the other being in parallel with it (Fig. 3, p. 628). On sending a steady current through the system, it divides between the wire spiral, S, and the lamp, L^1, and I adjust the strength of this current so that the lamp, L^1, is barely visibly red hot. On interrupting suddenly this electric current, the lamp, L^1, flashes up for a moment. We recognise that we have here to consider an inertia effect familiar to us as the effect of the "self-induction" in the long coil of wire. Audiences in this room have been so carefully informed on many past occasions by brilliant and capable teachers, that I may spare you a reiteration of elementary facts concerning the self-induction or inductance of conducting circuits, and take it for granted that everyone here is intimately acquainted with them, and that you will recall to your recollection that when an electromotive force acts upon any closed electric circuit generating in it an electric current, this self-induction exhibits itself by delaying or retarding the rise of the current strength to its full or its maximum value; and that, similarly, when the electromotive force is withdrawn, it operates to give the current a persistence, or to retard the rate of reduction of the current strength. The convenient term "time-constant" of a circuit is employed to denote that time, expressed in fractions of a second or any other unit, which must elapse before a current rises to a certain definite fraction of its full value, when a steady electromotive force acts upon that circuit.

FIG. 3.



I will next beg you to turn a moment's attention to the electro-dynamic actions or forces which are brought into play when a circuit of any kind is subjected to electro-magnetic induction in a magnetic field. Consider, for instance, a ring of copper hanging in front of the pole of an electro-magnet (Fig. 4), having the plane of the ring perpendicular to the lines of magnetic force proceeding out from the pole.

FIG. 4.



Let the magnet be an electro-magnet, and let the pole be suddenly made a north or marked pole. Lines of magnetic force are thrust into the aperture of the ring. This magnetic flux, in accordance with a well-known law, generates an inductive electromotive force which causes a transient current to flow round the ring in a counter clockwise direction, as looked at *from* the north magnetic pole. The ring becomes virtually a *magnetic shell*, having a north pole facing the north pole of the exciting magnet. By the fundamental laws of action between currents and magnets established by Ampère, the ring experiences a slight repulsive force, due to the electro-dynamic action between the current in the ring and the magnetic pole. The generation of the momentary induced current in the ring is accompanied by an electro-dynamic impulse tending to thrust it away from the pole. Suppose, next, that the electro-magnet is demagnetised. The ring has generated in it a reverse induced current flowing in the same direction as the hands of a clock move when looked at from the magnetic pole. This is also accompanied by an electro-dynamic attraction of the ring towards the pole, but which is much more feeble than the previous repulsion. These attractions and repulsions are well seen when small disks of copper or aluminium are suspended in front of the poles of a powerful electro-magnet, which is alternately "made" and "broken." They have been particularly investigated by Mr. C. V. Boys.*

I will now ask you to consider what would happen if the coils of the electro-magnet were traversed by an alternating current? Furthermore, we shall first suppose that the copper ring has a zero time-constant; that is to say, the induced currents in the ring rise up and sink down in strength in exact synchronism with the changes in the inductive electromotive force acting on the ring. If the current flowing in the coils of the electro-magnet is represented as to changes in strength by a simple periodic curve, we may suppose that the magnetism of the core and the magnetic induction through the ring follow a similar law. It is very easy, then, to show that the induced electromotive force acting in the ring circuit, and hence the current in the ring, follows a similar law of fluctuation, but that the instant of maximum current in the ring coincides with the instant of reversal of magnetism in the electro-magnet. Under these circumstances we can represent the changing strength of the magnetic field in which the ring is immersed by a simple periodic curve, M, and the changes of current strength in the ring circuit by another simple periodic curve, C, shifted backwards relatively to the first by a quarter of a wave length (Fig. 5).

Fig 5.

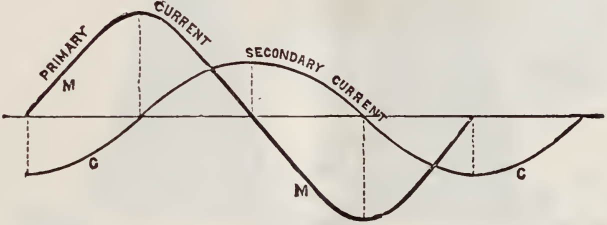
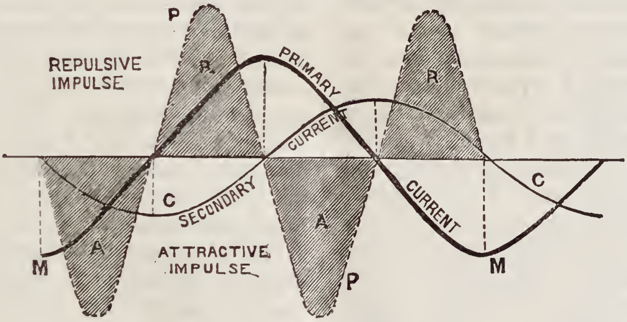


Fig. 6.



By Ampère's law, the force acting on the ring at any instant is proportional to the product of the instantaneous value of the surrounding field and this current strength. If we multiply together the ordinates of these two curves, M and C, and form a third curve, P, whose ordinate at every point is proportional to the product of the ordinates of the other curves (Fig. 6) at those points, we obtain a curve which represents the fluctuation of force at every instant acting upon the ring. This curve, P, is also a wave-like curve, lying symmetrically above and below the horizontal line. The positive and negative areas of this curve included between the curve and the horizontal line represent the impulses or time integrals of the forces which act upon the ring. These impulses are alternately positive and negative. This is equivalent to saying that under the circumstances assumed the ring gets a series of small pushes and pulls, or repulsions and attraction, which succeed each other at the same rate as the changes of magnetic polarity of the magnet. The series of rapidly alternating and equal impulses would result in leaving the ring apparently unmoved. No real conducting ring can, however, behave in this fashion, because every ring has a sensible

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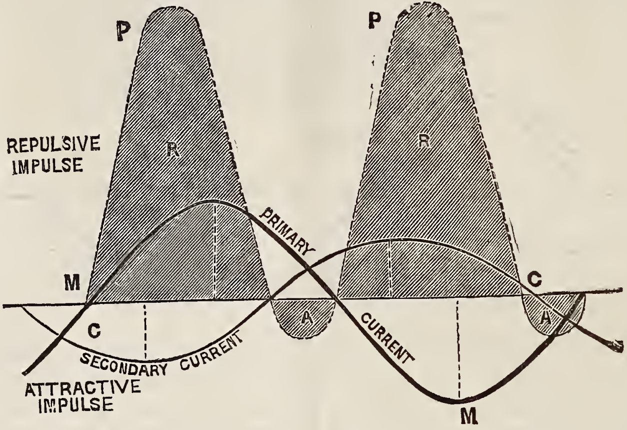
* On a "Magneto-Electric Phenomenon." By C. V. Boys, F.R.S. Proc. Phys. Soc., London, Vol. vi., p. 218.

"time-constant." Let us next see how the above statements will be modified if the ring has such a sensible self-induction that the current induced in the ring lags behind the inducing electromotive force in phase. Repeating the above construction for a force curve, on the assumption that the instant of maximum of the current in the ring occurs later than the instant of reversal of magnetism in the magnet, it is easy to see that the force curve consists now of two very unequal parts. It is not symmetrically situated with respect to the horizontal lines (see Fig. 7). The area of the hummocks (shaded portions) which lie above the datum line, and which represent the repulsive impulses on the ring, are much larger than the area of the hummocks below the datum line, and which represent the attractive impulses acting on the ring. This means to say, that the ring when possessing self-induction experiences on the whole a repulsive force, or a series of repulsive impulses, when immersed in such an alternating magnetic field radiated from a magnetic pole; and this repulsive force will be, within certain limits, more pronounced, other things being equal, the greater the time-constant of the circuit. You see clearly, therefore, that a ring or disc of copper in which the induced currents lag behind the inducing electromotive force in phase must experience a repulsive force when this inducing electromotive force is caused by a rapid flux backwards and forwards of lines of magnetic forces perforating through the ring or disc. The realisation of this inference in a striking manner is the first of a series of remarkable experiments on this subject due to Prof. Elihu Thomson. We have on the table an electro-magnet suitable for these experiments, which consists of a core of divided iron, surrounded by a coil in which I can cause to circulate a powerful alternating current of 40 to 50 ampères. Let us, however, begin with an experiment in which we employ a continuous current to energise the core. I give you, in Prof. Elihu Thomson's own words,* an account of this preliminary experiment :—

FIG. 7.



"In 1884, while preparing for the International Electrical Exhibition at Philadelphia, we had occasion to construct a large electro-magnet, the cores of which were about 6 in. in diameter and about 20 in. long. They were made of bundles of iron rod about 5-16ths of an inch in diameter. When complete, the magnet was energised by a current from a continuous-current dynamo, and it exhibited the usual powerful magnetic effects. It was found also that a disc of sheet-copper of about 1-16th of an inch in thickness, and 10 in. in diameter, if dropped flat against a pole of the magnet, would settle down softly upon it, being retarded by the development of currents in the disc, due to its movement in a strong magnetic field, and which currents were of opposite direction to those in the coils of the magnet. In fact, it was impossible to strike the magnet pole a sharp blow with the disc, even when the attempt was made by holding one edge of the disc in the hand and bringing it down forcibly towards the magnet. In attempting to raise the disc quickly off the pole a similar but opposite action of resistance to movement took place, showing the development of currents in the same direction as those in the coils of the magnet, and which currents, of course, would cause attraction as a result. The experiment could be tried in another way. Holding the sheet of copper by one edge, just over the magnet pole (Fig. 8), the current in the magnet coils was cut off by shunting them. There was felt an attraction of the disc, or a dip towards the pole. The current was then put on by opening the shunting switch, and a repulsive action or lift of the disc was felt. The actions just described are what would be expected in such a case, for when attraction took place currents had been induced in the disc in the same direction as those in the magnet coils beneath it, and when repulsion took place the induced current in the disc was of opposite character or direction to that in the coils. Now let us imagine the current in the magnet coils to be not only cut off, but reversed back and forth. For the reasons just given, we find that the disc is attracted and repelled alternately; for whenever the currents induced in it are of the same direction with those in the inducing or magnet coil, attraction will ensue, and when they are opposite in direction repulsion will be produced. Moreover, the repulsion will be produced when the current in the magnet coil is rising to a maximum in either direction, and attraction will be the result when the current of either direction is falling to zero, since in the former case opposite currents are induced in the disc, in accordance with well-known laws; and in the latter case currents of the same direction will exist in the disc and the magnet coil. The disc might, of course, be replaced by a ring of copper or other good conductor, or by a closed coil of bare or insulated wire, or by a series of discs, rings, or coils superposed, and the results would be the same."

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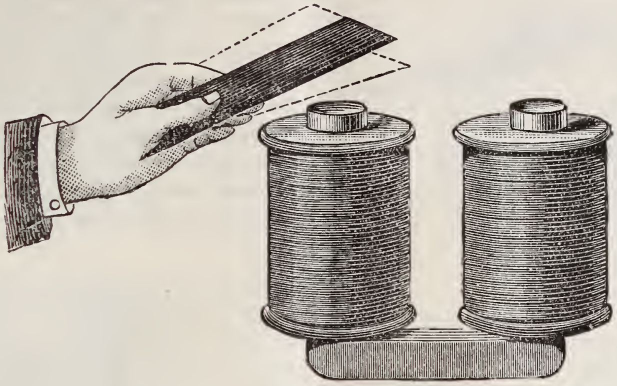
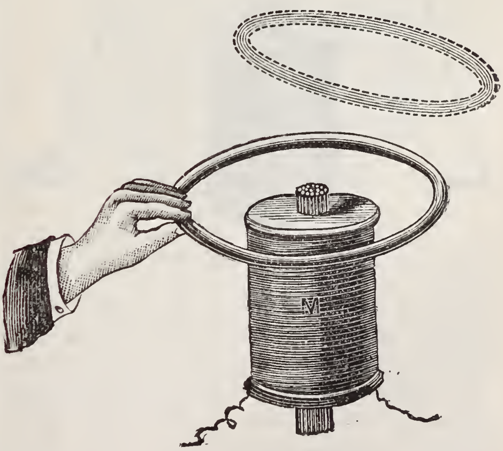
* See the *Electrical World*, May, 1887, p. 258; or the *Electrical Engineer* (American), June, 1887, p. 211 :—"Novel Phenomena of Alternating Currents," by Elihu Thomson.

FIG. 8.



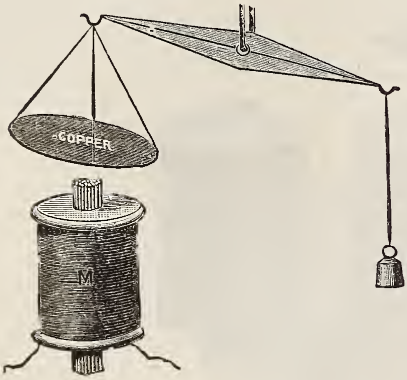
We have already seen that in an alternating field the electro dynamic impulses so experienced by the disc or ring are alternately attractive and impulsive, and that when the circuit possesses a sensible self-induction, the repulsive impulses overpower the attractive ones, and their repetition constitutes a repulsive force. Before adding a few more words of explanation, permit me to show you some of these electro-dynamic repulsions produced by an alternating electro-magnet. Here is a copper ring, and I lay it upon the top of this electro-magnet, having a divided iron core and excited by a powerful alternating current. On energising the magnet, the ring jumps up in the air (Fig. 9). If a copper plate is hung like a scale pan from a balanced beam, and placed over the magnetic pole, it gives evidence of being strongly repelled the moment we pass the current through the coils

FIG. 9.



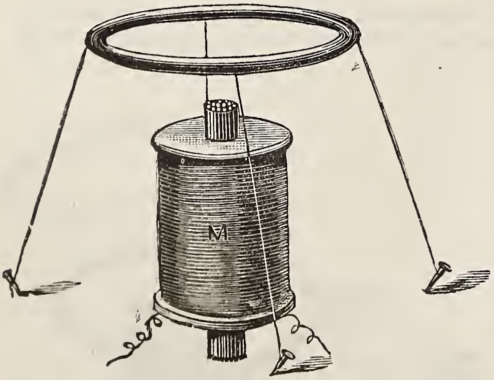
of the magnet (Fig. 10). Instead of employing copper rings or copper plates, we can use closed coils of thick wire, either insulated or not. If, however, our plates or rings have a radial slit made in them, or if our coils of wire are not closed-circuit coils, all the effects vanish.

FIG. 10.



So strong is this repulsion, with proper appliances, that light copper rings tethered by strings, may be held suspended in the air against the force of gravity, the upward electro-magnetic repulsion overcoming their weight, and holding them, like Mahomet's fabled coffin, floating in the air (Fig. 11).

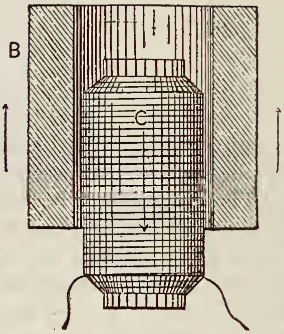
FIG. 11.



In cases where we are dealing only with impulsive effects, aluminium rings or discs give most marked results, because aluminium has the highest conductivity per unit of mass; but in the cases like those just considered, where what is required is the greatest force effect, copper or silver gives a better result than aluminium, because they have the highest conductivity per unit of volume. In Mr. Boys's experiments, if I remember rightly, he found aluminium the best to employ. In these cases of electro-dynamic repulsion, the force effect depends essentially upon the lag of the induced current, or its retardation in phase behind that of the inducing field, and, other things being equal, this is proportional to the conductivity of the circuit. I will pass before your view a series of diagrams intended to represent various cases and modes of production of these repulsive effects, giving you descriptions of them in Prof. Elihu Thomson's own words. He says:—

"This preponderating repulsive effect may be utilised or may show its presence by producing movement or pressure in a given direction, by producing angular deflection as of a pivoted body, or by produciug continuous rotation in a properly organised structure.

FIG. 12.

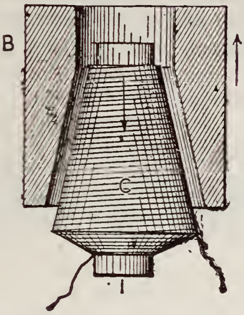


"In Fig. 12, C is a coil traversed by alternating currents, B is a copper case or tube surrounding it, but not exactly over its centre. The copper tube, B, is fairly massive, and is the seat of heavy induced currents. There is a preponderance of repulsive action tending to force the two conductors apart in an axial line. The part B may be replaced by concentric tubes slid one in the other, or by a pile of flat rings, or by a closed coil of coarse or fine wire, insulated or not. If the coil C, or primary coil, is provided with an iron core, such as a bundle of fine iron wires, the effects are greatly increased in intensity, and the repulsion with a strong primary current may become quite vigorous, many pounds of thrust being producible by apparatus of quite moderate size.

"The forms and relations between the two parts, C and B, may be greatly modified, with the general result of a preponderance of repulsive action when the alternating currents circulate.

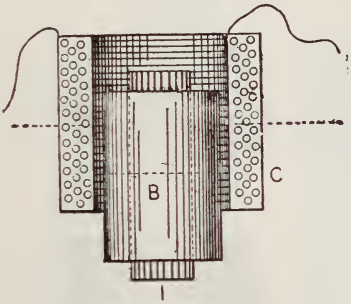
"Fig. 13 shows the part, B, of an internally tapered or coned form, and, C, of an externally coned form, wound on an iron wire bundle, I. The action in Fig. 12 may be said to be analogous to that of a plain solenoid with its core, except that repulsion, and not attraction, is produced; while that of Fig. 13 is more like the action of tapered or conically-wound solenoids and taper cores. Of course, it is unnecessary that both be tapered. The effect of such shaping is simply to modify the range of action and the amount of repulsive effort existing at different parts of the range.

FIG. 13.



"In Fig. 14 the arrangement is modified so that the coil, C, is outside, and the closed band or circuit, B, inside and around the core, I. Electro-inductive repulsion is produced as before.

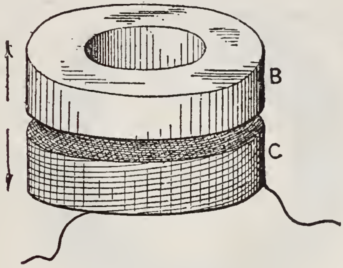
FIG. 14.



"It will be evident that the repulsive actions will not be mechanically manifested by axial movement or effort, when the electrical middles of the coils or circuits are coincident. In cylindrical coils, in which the current is uniformly distributed through all the parts of the conductor section, what I here term the electrical middle, or the centre of gravity of the ampère turns of the coils, will be the plane at right angles to its axis at its middle, that of B and C in Fig. 14 being indicated by a dotted line. To repeat, then, when the centres or centre planes of the conductors (Fig. 14) coincide, no indication of electro-inductive repulsion is given, because it is mutually balanced in all directions; but when the coils are displaced a repulsion is manifested, which reaches a maximum at a position depending on the peculiarities of proportion and distribution of current at any time in the two circuits or conductors.

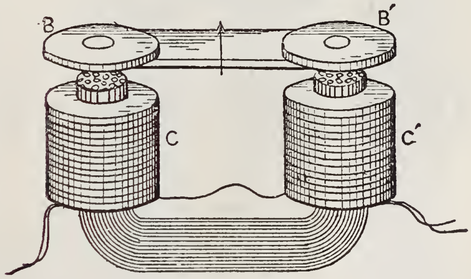
"In Fig. 15, B represents a copper ring, and C an annular coil placed parallel thereto; and an iron core or wire bundle placed in the common axis of the two coils, shows the repulsive action when an alternating current is passed through C. B may be simply a disc or plate of any form, without greatly affecting the nature of the action produced. It may also be composed of a pile of copper washers or a coil of wire, as before indicated.

FIG. 15.



"An arrangement of parts somewhat analogous to that of a horseshoe electro-magnet and armature is shown in Fig. 16.

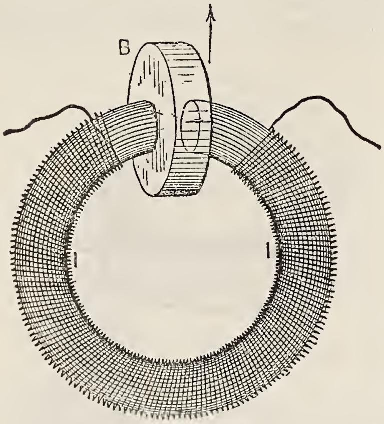
FIG. 16.



The alternating-current coils, C C′, are wound upon an iron wire bundle bent into U-form, and opposite its poles is placed a pair of thick copper discs, B B′, which are attracted and repelled, but with an excess of repulsion depending on their form, thickness, &c.

"If the iron core takes the form of that shown by I I, Fig. 17 (p. 634), such as a cut ring with the coil, C, wound thereon, the insertion of a heavy copper plate, B, into the slot or divided portion of the ring, will be opposed by a repulsive effort when alternating currents pass in C. This was the first form of device in which I noticed the phenomenon of repulsive preponderance in question. The tendency is to thrust the plate, B, out of the slot in the ring, excepting only when its centre is coincident with the magnetic axis joining the poles of the ring between which B is placed.

Fig. 17.



"If the axes of the conductors (Fig. 15) are not coincident, but displaced, as in Fig. 18, then, besides a simple repulsion apart, there is a lateral component or tendency, as indicated by the arrows. Akin to this is the experiment illustrated in Fig. 19. Here the closed conductor, B, is placed with its plane at right angles to that of C, wound on a wire bundle. The part, B, tends to move toward the centre of the coil C, so that its axis will be in the middle plane of C, traverse to the core, as indicated by the dotted line. This leads us at once to another class of actions, *i.e.*, deflective actions.

Fig. 18.

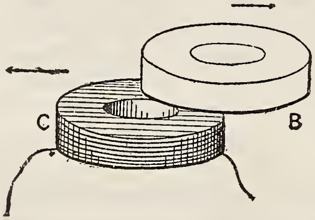
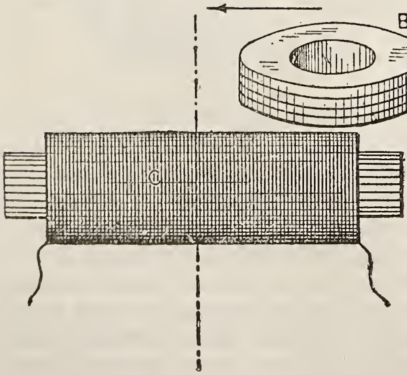


Fig. 19.



"When one of the conductors, as B (Fig. 20), is composed of a disk or, better, of a pile of thin copper disks, or of a closed coil of wire, is mounted on an axis, X, transverse to the axis of coil C, through which coil the alternating current passes, a deflection of B to the position indicated by dotted lines will take place, unless the plane of B is at the start exactly coincident with that of C. If slightly inclined at the start, deflection will be caused as stated. It matters not whether the coil, C, incloses the part, B, or be inclosed by it, or whether the coil, C, be pivoted, and B fixed, or both be pivoted. In Fig. 21 the coil, C, surrounds an iron-wire core, and B is pivoted above it, as shown. It is deflected, as before, to the position indicated in dotted lines.*

Fig. 20.

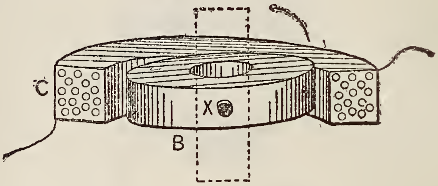
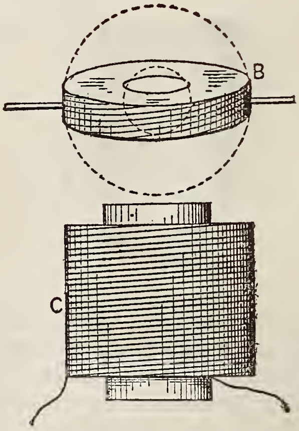


Fig 21.



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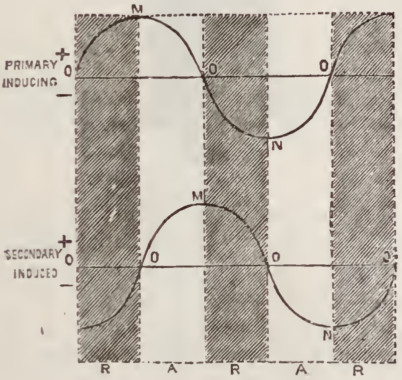
* This deflection by an alternating current of a copper disc suspended within a coil with its plane inclined to the plane of the coils, I myself noticed independently, in March, 1887, and subsequently described a copper-disc galvanoscope for alternating currents, based on this fact (see *The Electrician*, May 6, 1887). I did not, at the time, know how thoroughly Prof. Thomson had explored the phenomena, but the substantial explanation of it had already occurred to me.

"It is important to remark here that, in cases where deflection is to be obtained, as in Figs. 20 and 21, B had best be made of a pile of thin washers or a closed coil of insulated wire, instead of a solid ring. This avoids the lessening of effect which would come from the induction of currents in the ring B, in other directions than parallel to its circumference."

Returning for a moment to the theory of these repulsive and deflective actions, it will repay us to consider it in the form placed before us by Prof. Thomson, in his first paper on the subject, read before the American Institute of Electrical Engineers, May 18, 1887. He says:—"It may be stated as certainly true that, were the induced currents in the closed conductor unaffected by any self-induction, the only phenonema exhibited would be alternate equal attractions and repulsions, because currents would be induced in opposite directions to that of the primary current when the latter current was changing from zero to maximum positive or negative current, so producing repulsion; and would be induced in the same direction when changing from maximum positive or negative value to zero, so producing attraction.

"This condition can be illustrated by a diagram, Fig. 22. Here the lines of zero current are the horizontal straight lines. The wavy lines represent the variations of current strength in each conductor, the current in one direction being indicated by that portion of the curve above the zero line, and in the other direction by that portion below it. The vertical dotted lines simply mark off corresponding portions of phase or succession of times.

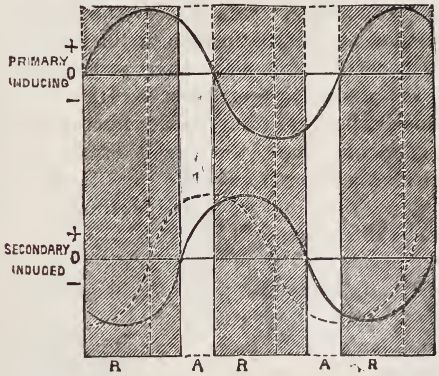
FIG. 22.



"Here it will be seen that in the positive primary current descending from M, its maximum, to the zero line, the secondary current has risen from its zero to M^1, its maximum. Attraction will therefore ensue, for the currents are in the same direction in the two conductors. When the primary current increases from zero to its negative maximum, N, the positive current in the secondary closed circuit will be decreasing from M^1, its positive maximum, to zero; but, as the currents are in opposite directions, repulsion will occur. These actions of attraction and repulsion will be reproduced continually, there being a repulsion, then an attraction, then a repulsion, and again an attraction, during one complete wave of the primary current. The letters R, A, at the foot of the diagram, Fig. 22, indicate this succession. (The shaded portions in the diagrams represent the time during which the force between the primary and secondary circuits is a repulsive force.)

"In reality, however, the effects of self-induction in causing a lag, shift, or retardation of phase in the secondary current, will considerably modify the results, and especially so when the secondary conductor is constructed so as to give to such self-induction a large value. In other words, the maxima of the primary or inducing current will no longer be found coincident with the zero points of the secondary currents. The effect will be the same as if the line representing the wave of the secondary current in Fig. 22 had been shifted forward to a greater or less extent. This is indicated in diagram, Fig. 23. It gives, doubtless, an exaggerated view of the action, though from the effects of repulsion which I have produced I should say it is by no means an unrealisable condition.

FIG. 23.



"It will be noticed that the period during which the currents are opposite, and during which repulsion can take place, is lengthened at the expense of the period during which the currents are in the right direction for attractive action. These differing periods are marked *r*, *a*, &c., or the period during which repulsion exists is from the zero of the primary or inducing current to the succeeding zero of the secondary or induced current; and the period during which attraction exists is from the zero of the induced current to the zero of inducing current. (It will be seen that the shaded portions in diagram 23 have been widened out at the expense of the unshaded parts.)

"But far more important still in giving prominence to the repulsive effect than this difference of effective period, is the fact that during the period of repulsion both the inducing and induced currents have their greatest values, while during the period of attraction the currents are of small amounts comparatively. This condition may be otherwise expressed by saying that the period during which repulsion occurs includes all the maxima of current, while the period of attraction includes no maxima. There is then a repulsion due to the summative effects of strong opposite currents for a lengthened period against an attraction due to the summative effects of weak currents of the same direction during a shortened period, the resultant effect being a greatly preponderating repulsion.

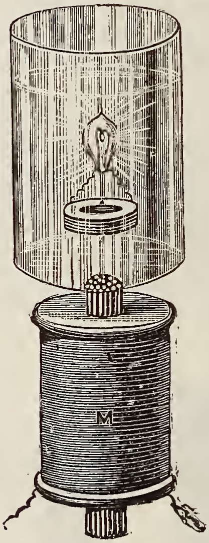
"It is now not difficult to understand all the actions before described, as obtained with the varied relations of coils, magnetic fields, and closed circuits. It will be easily understood, also, that an alternating-magnetic field is in all respects the same as an alternating-current coil in producing repulsion on the closed conductor, because the repulsions between the two conductors are the result of magnetic repulsions arising from opposing fields produced by the coils when the currents are of opposite directions in them."

One of the most beautiful of Prof. Thomson's experiments illustrating this repulsion can, I think, be shown to you now.

An incandescent lamp is attached to the terminals of a coil of wire, and the coil and lamp floated in water or hung from a scale beam (Fig. 24) over the pole of an alternating magnet. The coil and lamp form, as it were, a balloon and car floating in space, and placed in a magnetic field. When that magnetic field is rapidly alternated by exciting the magnet, the induced currents created in the coil make themselves evident by illuminating the lamp, and the repulsive electro-dynamic action shows itself by lifting the lamp and coil upwards through the water or the air.

The same experiment renders it possible to show the effect of magnetic screening very prettily. If I introduce a plate of copper between the magnet pole and the induction coil attached to the lamp, the copper "screens" the coil from the inductive action of the pole, and the light of the lamp disappears. I must next direct your attention to some curious effects which are found to exist when two conducting circuits are exposed to the magnetic flux from an alternating magnetic pole, and which depend upon the interaction of the currents induced in each respectively. Professor Thomson embodies these facts now to be considered in four laws, which may be briefly stated as follows :—

FIG. 24.



1. If two or more closed circuits are similarly affected inductively by an alternating magnetic field they will attract one another, and tend to move into parallelism.

2. Iron or steel masses placed in an alternating field give rise to shifting magnetism or lines of force moving laterally, and may, therefore, act to move closed circuits in the path of such shifting lines.

3. Closed circuits in alternating magnetic fields or fields of varying intensity give rise to shifting magnetism, or lines of force moving laterally to their own direction, and may, therefore, act to move other closed circuits in the path of such lines.

4. Iron or steel masses may, when placed in an alternating magnetic field, interact with other such masses, or with closed electric

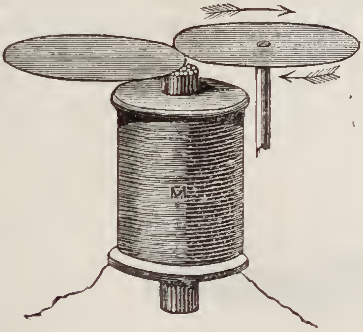
circuits, so as to produce movement of such masses or circuits relatively, or give rise to tendencies to so move, the effects depending on continual adaptations of shifting magnetism and retained magnetism relatively.

It is a simple matter to illustrate these principles; and the experiments, which are designed so to do, bring before us some striking peculiarities of the action of magnetic force upon closed circuits, and upon masses of conducting and magnetisable matter.

Returning, first, to the simple experiment of a copper ring repelled by an alternating pole, we find that if we add a second ring under the first, they both attract one another, and the two rings are supported and repelled as if they were one ring. It is obvious that at any instant the induced currents in both rings are in the same direction, and hence they attract one another.

Such an attractive action can be made to produce continuous rotation. We have only to place a copper ring or plate over the alternating current coil or pole, and then bring a copper disc, free to revolve on pivots, into proper position relatively thereto. This can best be done by placing the ring or plate so as to be somewhat to one side of the pole, so as to "shade" part of it, as it were, while a part of the pivoted disc is placed under or over it, in front of the alternating pole. The disc then begins to revolve rapidly on its pivot (Fig. 25).

FIG. 25.

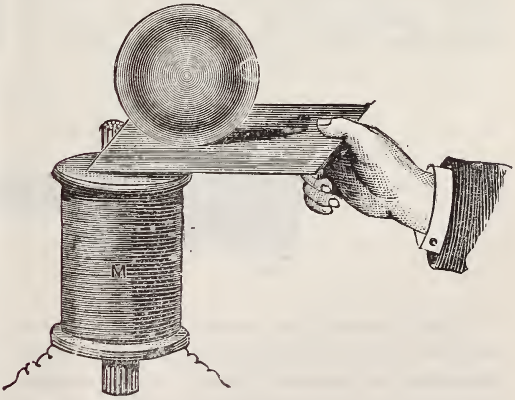


A little consideration shows that in this case the fixed copper plate shields a portion of the pivoted plate. The currents induced in the fixed plate attract the non-symmetrically placed induced currents in the other disc, and exert a tangential action or couple upon it, tending to pull it round. The continual repetition of this action as each portion of the place becomes in turn the seat of maximum inductive action, results in a continual revolution of the plate. Two pivoted discs may be used instead of one, and it will be found that they may each "shade" a portion of the pole, and if made to overlap, they will pull each other round and revolve in opposite directions when the alternating pole acts upon them.

This principle of "shading" a portion of the magnetic pole, and hence causing an unsymmetrical distribution of induced currents in a conducting body capable of revolution on a pivot, has been developed by Prof. Thomson in many extraordinary ways.

Floating, for instance, a hollow sphere of copper on the surface of water in a glass vessel, he places this over an alternating magnetic pole. If the pole is placed directly under the sphere, the electro-magnet action would, as before explained, result in a repulsive force acting upon the disc. If, however, a sheet of copper is placed half over the pole so as to "shade" a portion of the copper sphere, the currents induced in it are unsymmetrically situated with respect to its centre, and react upon the current induced in the plate. Hence, the electro-magnet action resolves itself into a torque or couple, causing the ball to spin rapidly upon its centre, and take up a rapid rotation. So considerable is the rotational force brought to bear that the ball will rotate when merely laid on a sheet of copper, even overcoming the friction of such rotation on its equatorial line, provided that the ball and supporting plate are so held over an alternating pole that the plate shields a portion of the sphere (Fig. 26). Given this principle that by properly "shading" a pole from a portion of a solid body capable of revolution round a line or axis, it is easy to see that countless forms of electromotor can be designed.

FIG. 26.



A sort of anemometer with copper discs for cups, resembling the cross of a Crookes' radiometer, can be set in rapid rotation by an alternating pole, if a copper screen is placed so as to shade one side of it.

This unsymmetrical development of the induced currents can be produced by a suitable disposition of the magnetic pole alone. Thus we may place a cone or wedge of iron on the alternating pole, and hold near it a copper ring mounted so as to be able to revolve (Fig. 27). The copper cylinder or wheel revolves rapidly under the action of the periodic field, and its direction of motion is such that it seems to be blown around by a blast from the end of the magnetic cone. Prof. Thomson has constructed a curious electrical gyroscope as follows: a vertical pivot projects from the centre of an alternating pole (Fig. 28), upon which is pivoted a horizontal rod bearing a counterpoise, and a copper wheel, preferably with an iron core attached to it, gyroscope fashion, by means of a copper frame. The copper frame is placed in an inclined position with respect to the horizontal. Under these circumstances a vigorous rotation is communicated to the gyroscope wheel when the alternating field acts upon it. The copper frame shields one side of the wheel more than the other, and, as a result, the induced currents in the copper wheel are unsymmetrically placed with respect to its axes of rotation, and it experiences a violent torgue.

FIG. 27.

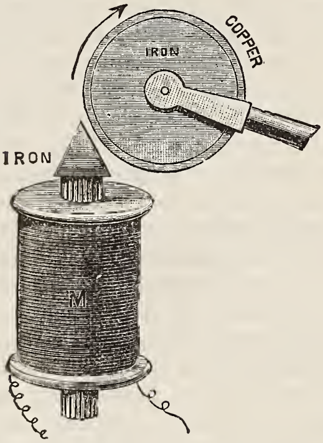
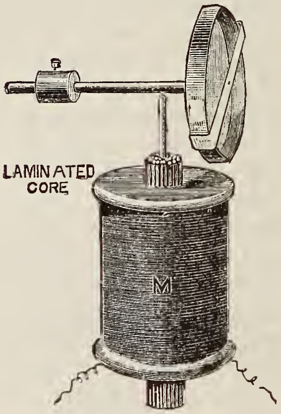
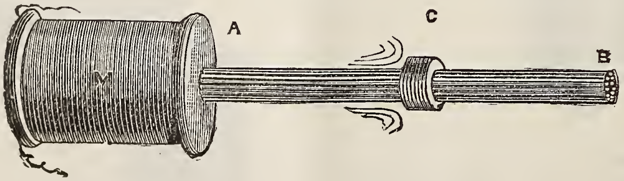


FIG. 28.



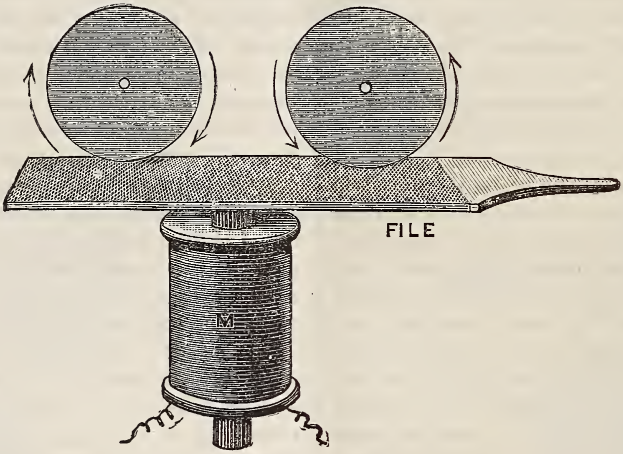
These experiments can, by a little ingenuity, be endlessly multiplied when once the fundamental principle is grasped. Bodies can be made to rotate and move, taking their movements from the magnetised space in which they are placed, and without being supplied with current from an external source.

FIG. 29.



Prof. Thomson has, however, studied some curious cases of magnetic motion, in which rotations are obtained when iron or copper pivoted discs are placed near to iron or steel bars, in which the propagation of magnetism is throttled by closed circuits. If a longitudinally laminated iron bar has a closed copper band or coil placed round it at one point, and if such a bar is made magnetic by a periodic current traversing a magnetising coil embracing another part, this structure becomes capable of rotating iron or copper discs held near it. The explanation of this effect is probably to be found in the fact that the closed embracing coil tends to throw off the magnetic lines of force laterally at that point. Consider a bar (Fig. 29), A B, in which lines of magnetic force are being established in the direction from A to B. That is to say, let magnetic induction be increasing in the bar in a direction from A to B, at C let there be a closed coil embracing the bar, the magnetic induction during its period of increase is setting up in this circuit an electromotive force which establishes in the circuit a current whose lines of force are opposed to the primary induction inside the coil, and, therefore, in the iron included in the coil, but in the same direction outside the coil, and, therefore, outside the iron. The result is as if the lines of primary magnetic induction in the iron were shed off laterally and escaped round the coil. When the magnetic induction in the iron, due to the magnetising coil, is made periodic, this action will create a kind of lateral pulsation of the magnetic lines of force in the neighbourhood of the closed coil If, then, a movable conductor is held near such a magnetically-throttled bar, it will be subjected to a displacement of lines of magnetic force through it laterally, and will hence have eddy electric currents generated up in it. These currents, persisting into the period of reversal of the field in virtue of self-induction in the conductor, will cause the portion of the conductor in which they are set up to be continuously repelled, and hence to take up a motion of rotation. A ring of cast-iron, having a closed coil wound on it at one point, is held so that another point on its circumference, 90° removed from the closed coil, is on the pole of an alternating magnet. An iron disc, centrally pivoted and held concentric with the ring, is rotated when the magnet is energised by an alternating current. It is not even necessary to have a closed coil on one part of the active magnetic bar, provided that this bar is not laminated, or, better still, is made of hard steel. In these cases there is a lag in magnetisation, due to either eddy currents set up in the bar or to hysteresis, and the result is a lateral escape of lines of force out of the bar. When it is held with one extremity on an alternating magnetic pole, there is in these cases an action which is a true "magnetic self-induction." In the case of electric circuits, if we join in parallel two circuits, one having very small ohmic resistance and very high self-induction, and the other very large ohmic resistance and small self-induction, a sudden flow of current chiefly selects the path of least self-induction for its flow during the variable period, although during its steady period it will chiefly flow by the path of smallest ohmic resistance ; so in the case of a magnetic and conductive circuit of low magnetic and electric resistance (iron), shunted by a path of high magnetic and electric resistance (air), rapid variations of magnetic induction bring about a state of things in which the magnetic induction seems to chiefly select the path not of least but of greatest magnetic resistance during the variable period. Time will not permit me to develop at greater length the analogies of the magnetic and electric circuits under the conditions of rapidly periodic magnetic induction and electric current ; but there are many suggestive ideas which arise when we place before our minds the notion of a magnetic self-induction which is the consequence of a time-element coming into action in the setting up of induction in a magnetic and conductive circuit, and due to the production of electric eddy currents, just as the electro-magnetic or ordinary self-induction is the consequence of the time element coming into action in the setting up of an electric current, and due to the production of a surrounding magnetic field. Just as the rise of current strength under an impressed electromotive force, acting in a conducting circuit, is retarded by linking that conductive circuit with a magnetic circuit, so the rise of magnetic induction under an impressed magnetising force acting on a magnetic circuit is retarded by linking that magnetic circuit with an electric conducting circuit. I am under the impression that Mr. Oliver Heaviside has developed these notions in a mathematical form, but am unable at the moment to place my hands upon the results. The effect, however, of a bar of unlaminated iron when surrounded by a magnetising coil at one end, and traversed by a periodic current, is to cause rotation in copper or iron pivotted discs held near it, or when such a bar of non-laminated iron is abutted on the pole of an alternaring magnet. A bar of steel, even if not laminated, is able to cause brisk rotations in copper or iron discs under the same circumstances. With hardened steel the action is more marked. Here the hysteresis retards the propagation of the magnetic wave. By laying a large file flatwise against the alternating magnetic pole at about the middle of the file, discs of copper or iron may be kept revolving if held over those portions of the file which project from the pole of the magnet (Fig. 30, p. 640). In this case the magnetic retardation in the bar is brought about by its own physical structure, and not by embracing it with a closed conducting circuit. The result is, however, the same in kind; there is a sluggishness in the establishment of the magnetic induction on the steel or iron under the action of magnetising force, which partly depends on the eddy currents in the mass of metal, and partly on hysteresis. As a consequence, we have a periodic lateral displacement of the field. The question of a magnetic leakage dependent on a retardation of induction deserves special attention in the case of commercial alternate-current transformers. Time will not permit me to enlarge on it here to any great extent; but I may observe that in the design of closed-iron circuit transformers this magnetic leakage should not be neglected.

Fig. 30.



In a closed iron circuit embraced at one part by a magnetising coil, and subjected to rapidly reversed magnetic force, the magnetic induction does not confine itself wholly to the path of least magnetic resistance, viz., the iron path, but takes a short circuit in part across the interior air space. This waste field may in badly designed transformers be something considerable. I believe that an important point to hold in view in transformer construction is to subject the iron circuit uniformly to the magnetising force, by embracing all portions of the iron circuit with primary windings, and not locating the windings simply at one part. There is then a tendency to check the production of waste field by the lateral budging-out of the magnetic lines of force from the iron. In Fig. 31 is a diagram illustrating the arrangement of primary and secondary coils, most favourable for the production of waste field, and in Fig. 32 the arrangement least favourable for the same.

Fig. 31.

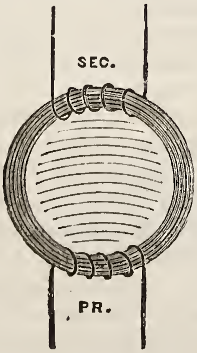
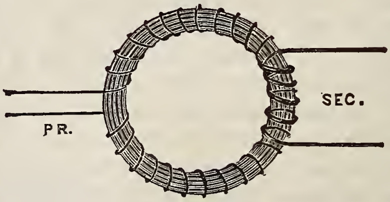


Fig. 32.

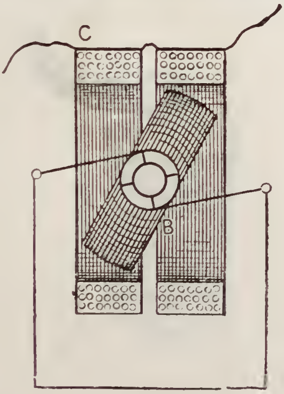


The foregoing experiments are of such a nature as obviously to force on us the thought that useful and perhaps important applications can be made in electro-magnetic machinery. Professor Elihu Thomson has, as you can imagine, not been slow to do this; for in him is united both a keen scientific sagacity and that clear mental vision, which enables him to pursue to its logical issue in practice the consequences of scientific discovery. He has already applied these principles to the construction of alternating-current indicators, alternating-current arc lamps, regulating devices for alternating currents, and to rotary motors for such currents. For current indicators, a pivoted or suspended copper band or ring, composed of thin washers piled together and insulated from one another, and made to carry a pointer or index, has been placed in the axis of a coil conveying alternating currents, whose amount or potential is to be indicated. Gravity or a spring is used to bring the index to the zero of a divided scale, at which time the plane of the copper ring or band makes an angle of, say, 15 to 20 degrees with the plane of the coil. This angle is increased by deflection more or less great, according to the current traversing the coil. The instrument can be calibrated for set conditions of use. Time would not permit of a full description of these arrangements as made up to the present.

In arc lamps the magnet for forming the arc can be composed of a closed conductor, a coil for the passage of current, and an iron wire core. The repulsive action upon the closed conductor lifts and regulates the carbons in much the same way that electro-magnets do when continuous currents are used. The electro-inductive repulsive action has also been applied to regulating devices for alternating currents, with the details of which I cannot now deal.

For the construction of an alternating-current motor, which can be started from a state of rest, the principle has also been applied, and it may here be remarked that a number of designs of such motors is practicable.

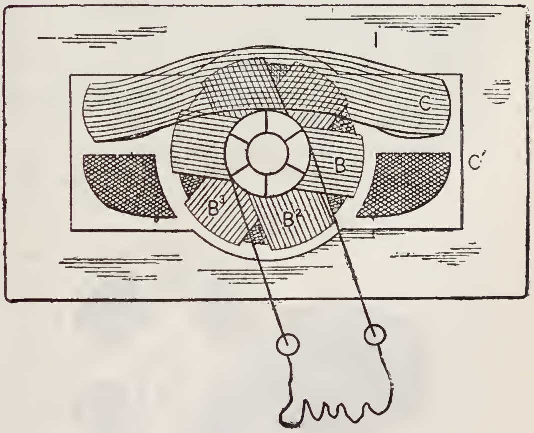
FIG. 33.



One of the simplest is as follows:—The coils, C, Fig. 33, are traversed by an alternating current, and are placed over a coil, B, mounted upon a horizontal axis transverse to the axis of the coil C. The terminals of the coil B, which is wound with insulated wire, are carried to a commutator, the brushes being connected by a wire, as indicated. The commutator is so constructed as to keep the coil B on short circuit from the position of coincidence with the plane of C, to the position where the plane of B is at right angles to that of C; and to keep the coil B open-circuited from the right-angled position or thereabouts to the position of parallel or coincident planes. The deflective repulsion exhibited by B will, when its circuit is completed by the commutator and brushes, as described, act to place its plane at right angles to that of C, but being then open-circuited, its momentum carries it to the position just past parallelism, at which moment it is again short-circuited, and so on. It is capable of very rapid rotation, but its energy is small. He has extended the principle to the construction of more complete apparatus. One form has its revolving portion or armature composed of a number of sheet-iron discs, wound as usual with three coils crossing near the shaft. The commutator is arranged to short-circuit each of these coils in succession, and twice in a revolution, and for a period of 90° of rotation each. The field coils surround the armature, and there is a laminated iron field structure completing the magnetic circuit.''

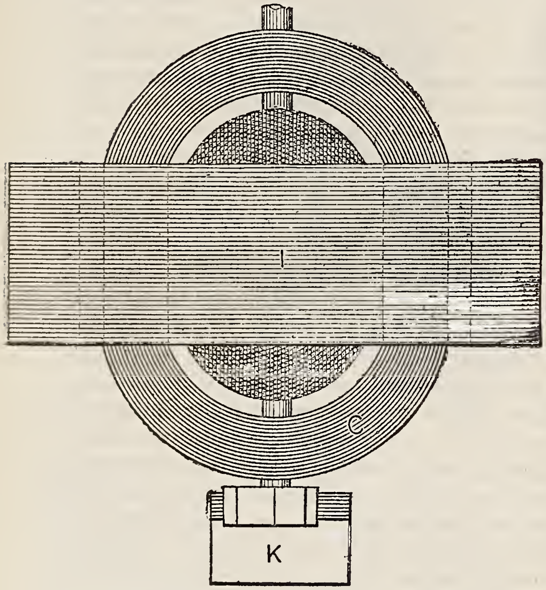
In Figs. 34 and 35, we have diagrams which will give an idea of the construction of the motor referred to. C C′ are the field coils or inducing coils, which alone are put into the actuating alternating circuit. I I is a mass of laminated iron, in the interior of which the armature revolves with its three coils, B, B^2,

FIG. 34.



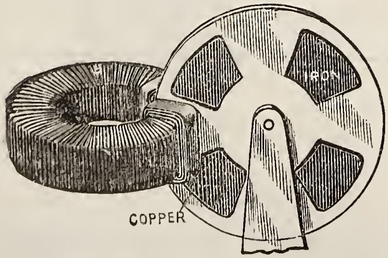
B^3, wound on a core of sheet-iron discs. The commutator short circuits the armature coils in succession in the proper positions to utilise the repulsive effect set up by the currents which are induced in them by the alternations in the field coils. The motor has no dead point, and will start from a state of rest and give out considerable power, but with what efficiency is not yet known. A curious property of the machine is that at a certain speed, depending on the rapidity of the alternations in the coil C, a continuous current passes from one commutator brush to the other, and it thus performs the function of converting some electric energy from an alternating to a continuous form.

FIG. 35.

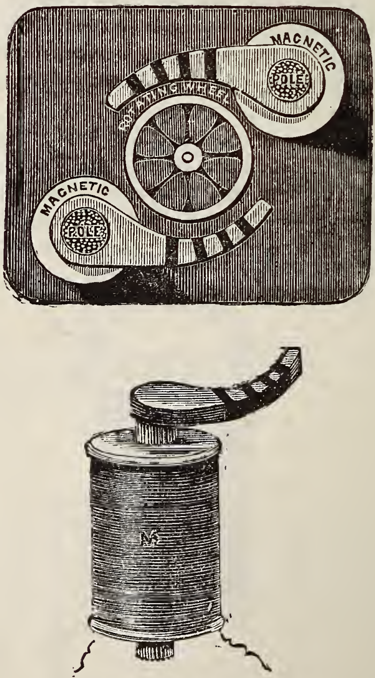


A small motor of a curious type has been made, utilising the principle of "shading" the pole by closed circuits. A laminated ring (Fig. 36) is wound over with wire, but has a slot cut through it, dividing the ring, and causing it to present two pole faces opposite to each other at the cut part. Each pole is arranged by a set of closed copper bands to be "shaded." A copper disc, free to turn on a shaft, is introduced by one edge into the air-gap in the magnet, and turns rapidly when the magnet is excited. A silver coin held just at the edge of the air-gap in such an alternating magnet with shaded poles, is drawn into the interpolar space and propelled with some force through the same; but a lead disc or coin of base metal is not acted upon nearly by the same force, owing to its inferior conductivity. I have left myself but little time to speak of numerous applications of these principles in alternating current meters. The well-known meter of Mr. Schallenberger was described to you here quite recently by Professor Forbes. There is, however, a new form of meter, designed by Messrs. Wright and Ferranti, which exhibits in a most beautiful manner, a practical application of some of these principles, which have briefly occupied our attention. In Fig. 37, we have a diagram of this meter. It consists in its latest form of a pair of vertical electro-magnets—magnets having divided iron cores. To the poles of these magnets are attached curved horns of divided iron, which lie in a horizontal plane.

FIG. 36.



FIGS. 37 AND 38.



These curved horns are magnetically throttled at intervals along their length with copper bands. The curved horns embrace a circular space, in which can revolve a light copper or iron shallow cylinder of thin metal. This cylindrical band forms the periphery of a light wheel capable of rotation on a vertical axis. Geared to this axis is a counting mechanism. The axis also carries a vane having mica blades. The electro-magnetic principle may be briefly described thus:—The throttling of the curved iron horns causes the rapidly reversed magnetism to take the form of a lateral diffusion of lines of force from the sides of the horns. In effect, a series of oppositely-named magnetic poles travels along the horn from the base, where it is in contact with the top of the electro-magnet, to the tip. These poles are represented by a series of bunches of lines of force setting out laterally from the sides of the horn, and travelling up it. The lateral passage of these lines of force through the metal band which forms the rim of the movable wheel generates in it eddy currents. These are continually repelled by the moving field producing them, and hence a motion of rotation is given to the wheel by the alternating magnetism of the magnetic poles. The speed of rotation, being retarded suitably by the vanes, can be made to be proportional to the current strength of the current exciting the magnets, and hence the total turns of the wheel in a given time to the total electric quantity flowing through the meter. A beautiful adaptation has here been made of the principles we have been briefly studying, and much more might be said in explanation, or, rather, in elucidation of the action of this meter did opportunity permit.

It would take me beyond the limits of the time during which I am permitted to trespass upon your attention, if I were to attempt to exhaust the list of electro-motor applications that have been made of these electro-magnetic repulsions. That is a subject important enough to deserve a separate treatment. In Berlin, not long ago, I saw a most ingenious form of self-starting alternating-current motor, the invention of Herr von Dolivo Dobrowolsky, in which the rotating portion was merely a solid iron cylinder constituting a commutatorless armature, revolving in an alternating field, and which acted in a perfectly marvellous manner. The region of practical invention here opened is a very wide one, and I have, therefore, ventured to direct your thoughts to it to-night, confident that its character in this respect deserves all the attention it can obtain, and that a firm foundation for such work is laid in these interesting researches of Professor Elihu Thomson.

DISCUSSION.

Mr. Preece, F.R.S., said the experiments which had been shown were, to some extent, a repetition of those which he had the pleasure of seeing last year at the Paris Exhibition performed by Professor Elihu Thomson himself. Anyone who saw the way in which Professor Thomson did those experiments, or had followed the way in which he had studied and developed this question, must feel that in him England had lost a worthy son and America had gained a great genius, and he did not suppose at the present moment there was in either hemisphere a more promising electrician. The development of electricity in America made its followers in England feel quite small, and they wondered how it was that they went ahead so fast on the other side of the Atlantic, and why men of talent and ability would go there. However, he hoped the day was not far distant when the pockets of capitalists in England would be open as freely to rising electricians as they were in America. He had felt the greatest pleasure in listening to this paper, having been almost bred and born under the wings of Faraday. In the early days of telegraphy, in 1853, they were much disturbed by remarkable effects on the wires which no one understood; Faraday's aid was called in, and he should always be proud to remember that he was appointed to act as Faraday's assistant, and did so during 1853 and 1854, and carried out many of his experiments. At that time Faraday was impressed with one idea, for he had just developed the principles which had been enunciated so clearly to-night. The mutual induction between wire and wire was then in his mind, the cause of nearly all the disturbances, and nearly everything which had been brought out during the last year or two with regard to alternating currents and their influence on each other was in Faraday's mind in those days, though they could not be developed. Those disturbances were thought by him to be due to some of the effects which had been seen to-night, but they could not then be shown, because in those days they were dealing with infinitesimal currents compared with the enormous currents which Mr. Thurnauer had been able to handle with perfect safety. The introduction of the electric light had brought into play immense power, and in consequence, the ideas which were simply fructifying in Faraday's imagination had been demonstrated as actual facts by Elihu Thomson and those working under his instruction. He remembered Faraday showing an experiment at the Royal Institution on one occasion where a current was sent through a very powerful magnet, and he showed that when the current was continuous no practical effect could be felt on passing a copper disc or steel knife before the holes, but when contact was rapidly made and broken the effect was precisely the same as if you attempted to cut cheese. This idea was taken up afterwards by Dr. Tyndall, and he showed at the Royal Institution an experiment similar to one just exhibited, where resistance to motion between the poles of a magnet was exactly the same as if one attempted to cut through a piece of cheese. They were gradually being brought to ask the question what was matter? They knew that one of the qualities of matter was resistance, and there was also this resistance in the mutual effect between electricity and magnetism. They were coming to the conclusion that, after all, there was nothing in matter, and matter was nothing. They did not know what matter was, neither did they know what this connection between electricity and magnetism was. Perhaps the most beautiful experiment was that of the development of light in a vessel of water. It was shown that when that vessel was placed over an electro-magnet, although there was absolutely nothing (according to the ordinary view) between the electric lamp and the magnet, yet light was produced. There were these rapid alternations of electricity in the wire round the electro-magnet, a rapid production of magnetism in the iron; something passed between that eletro-magnet and the vessel of water, the coil was repelled upwards, and floated in the water, and in that little globe of glass a brilliant light was produced. When the screens of copper were interposed between the electro-magnet and the glass vessel, the light disappeared, but the energy did not, it was apparent in the sound which was heard, for when the copper was placed between the two there was a loud sound, almost a roar, which showed that the energy was still there. It did not take the form of light but of heat, really, and the rapid alternations of heat caused the disc of copper to vibrate, probably by expansions and contractions. Whenever there were rapid alternations of electricity passing through wires, there were rapid variations of energy, and the whole atmosphere around was subject to them. When you had a wire, say between Deptford and London, conveying these great and rapid changes of electricity, the whole of the atmosphere round about London was under incessant changes of energy, which might, with suitable instruments, be observed. They were not observed by little glow lamps, which required an immense amount of energy to develop light, but if you had something which appealed to the ear, like the delicate and sensitive telephone, the rapid changes of electricity in a wire conveying rapid currents would give evidence of exactly the same changes of energy. If electrical engineers did not know how to prevent these changes of energy disturbing the telephone system, it would be practically impossible to convey currents of electricity from Deptford to London, because every single telephone in London would be disturbed with a roar much louder than they had heard from the copper plates. The great advantage of difficulties, however, was that they taught men somehow how to cure them, and while the transmission of currents had developed great difficulties, they had also shown how to get over them, and the result was that currents of electricity could now be conveyed through London of immense power without creating the slightest disturbance whatever. It was impossible to discuss this paper in detail. Professor Fleming had given many new facts and shown a great many experiments, and he could only compliment him on the skill with which he had brought out the facts, and thank Mr. Thurnauer for enabling them all to see the experiments, which only a few probably had the opportunity of witnessing at Paris.

The CHAIRMAN said he would at once ask the meeting to join in a cordial vote of thanks to Professor Fleming for his paper. It had given him all the more pleasure to preside, from the fact that he had spent a considerable portion of the early part of the year in America with Professor Thomson, in connection with some of his other work, and he had had many opportunities of seeing the extremely vigorous and practical manner in which Professor Thomson carried out the actual application of the very complex phenomena which he had investigated. Professor Fleming, in this paper, had spoken as if he were merely describing Professor Thomson's work, but every one who could appreciate the matter would understand that a description of work of such a kind could not be given by anyone who had not the most thorough knowledge of the subject himself, and also the very highest powers of making clear matters which were in themselves extremely difficult, although they did not sound so when so lucidly described. He would ask them to include in the vote of thanks Mr. Thurnauer, who had helped Professor Fleming so much in the experiments.

The vote of thanks having been passed unanimously,

Professor FLEMING briefly acknowledged the same, and then proceeded to describe in further detail some of the apparatus.

ADDITIONAL LECTURES.

Mr. LEWIS F. DAY delivered the second lecture of a course on "Design applied to Wood-Carving," on Thursday evening, 8th inst.

CANTOR LECTURES.

The third lecture of the course on "Sugar, Tea, Coffee, and Cocoa, their Origin, Preparation, and Uses," was delivered by Mr. RICHARD BANNISTER, on Monday evening, 12th inst., when the subject of Tea was specially dealt with.

These lectures will be printed in the *Journal* during the autumn recess.

APPLIED ART SECTION.

Tuesday, May 13, 1890; C. PURDON CLARKE, C.I.E., in the chair.

The paper read was on "The Use of Alloys in Art Metal Work," by Prof. W. C. ROBERTS-AUSTEN, F.R.S.

The paper and discussion will be printed in a future number of the *Journal.*

Miscellaneous.

CALIFORNIAN FRUIT PRODUCTION.

A correspondent, writing to the *Economiste Français*, says that at the present time California is one of the principal fruit-producing centres of the world. It is more particularly in the southern part of the State that this industry is the most developed, and Sacramento is the centre of it. It produces all kinds of fruits—pears, peaches, figs, grapes, &c. The pear, which is one of the choicest and most easily transportable of fruits, was the first to attract the attention of the grower, and was cultivated on a very considerable scale. The pear tree in California bears at the end of three years, but it is only in full bearing at the end of six or seven. An acre of ground, well planted and carefully attended to, should yield at the expiration of this period about 35,000 lbs. weight of fruit, worth £200. Grapes are of three descriptions—those for the table, for wine making, and for drying. Each description has its own special centre of production. Grapes for drying are grown in the valley of San Joaquin, those for wine making further to the north, and the table fruit is cultivated in the neighbourhood of Stockton and Sacramento. Southern California is distinguished by very varied climates, which admit of all descriptions of fruit culture. The choicest kinds of table grapes are those known as Tokay. A San Francisco paper—the *California*—states that over an area of fifteen acres planted with Tokay grapes, the vines being fourteen years old and well tended, the gross yield was valued at nearly £4,000. Deduction being made of the expense of cultivation, irrigation, transport, and commissions, the net product is estimated at £1,738, that is at the rate of £124 per acre. This, however, is stated to be an exceptional case. After grapes come the figs. These latter are cultivated in very large quantities in California, and there are many different descriptions. An attempt has been made to acclimatise the true Smyrna fig, but it has not hitherto been a success, although fruits have been grown very nearly resembling it but inferior in perfume. The choicest variety and the one most easily obtained is the fig called the "white Adriatic." At Ventura, where it is most successfully cultivated, one grower alone has planted a very large extent of ground, and estimates, judging from past results, that in ten years time his annual yield will amount to about 1,250 cart loads of fruit, which at the rate of one cent. a pound will produce an amount of £50,000. The fruit growers of California having a supply of fruits greater than is necessary for home consumption, are naturally desirous of finding outlets for their supplies, and for some years they have been endeavouring to establish markets on the Atlantic coasts. In the fruit season an exhibition of choice fruits is sent over the principal lines of the Union in a specially constructed wagon, which is called "California on wheels." The cost of this travelling exhibition is borne by the Board of Trade of the State of California and the Southern Pacific Company. At the same time the Board of Trade supports, not without considerable expense, at San Francisco, a permanent exhibition of fresh fruits. The Eastern States, the large cities such as New York, Boston, Philadelphia, and more in the west Chicago, and in the south St. Louis, equally receive regular supplies of fruits. Railways have been constructed to unite the principal producing centres of California with the great transcontinental lines, and to carry the fruits rapidly from one end of the country to the other. But no matter how abundant the yield may be, and the cheapness of transport, fresh fruits are still a luxury, and their sale cannot exhaust the production of California, so for some years now attention has been paid to developing the sale of preserved fruits. At first, these were prepared on the evaporation system, and the fruit was then packed in boxes. This industry has had an enormous development, and the manufacturers of tin boxes in California are considered among the most skilful and the richest in the world. Since 1887 the yield of fruit has been so abundant that the special apparatus for artificial evaporation have been insufficient, and recourse has therefore been had to natural evaporation by solar heat, but the latter system has not given, everywhere, satisfactory results. In the greater part, however, of California, the air is extremely dry, and the desiccation of fruits under the influence of the sun is, says the *Economiste*, absolutely perfect.

General Notes.

SMOKE PREVENTION.—A meeting has been convened at the Mansion-house, on Wednesday next, the 21st inst., by the committee for testing smoke-preventing appliances. The object of this committee the location of which is in Manchester, is to obtain, and eventually to publish, information as to the best apparatus and methods available for consuming fuel in manufacturing processes without the production of smoke. The committee are endeavouring to collect information as to the results of past experience, and they also propose to carry on tests by qualified persons of appliances for consuming coal smokelessly which are already at work, as well as to make tests of appliances and methods which cannot be adequately tested where they are in use. The committee are endeavouring to raise a guarantee fund, the amount of which is estimated at about £6,000, the cost of the work to be carried out amounting probably to about £3,000. Any person desirous of contributing, or in other ways promoting the objects of the committee, should communicate with Mr. Fred. Scott, the secretary, 44, John Dalton-street, Manchester.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evening, at Eight o'clock:—

MAY 21.—J. G. GORDON, "The Mannesmann Process for making Seamless Tubes." SIR FREDERICK BRAMWELL, Bart., D.C.L., F.R.S., will preside.

FOREIGN AND COLONIAL SECTION.

Tuesday afternoon, at Five o'clock:—

MAY 20.—A. LASENBY LIBERTY, "The Industrial Arts of Japan." Sir GEORGE BIRDWOOD, K.C.I.E., C.S.I., will preside.

INDIAN SECTION.

Thursday afternoon, at Five o'clock:—

JUNE 12.—SIR THEODORE C. HOPE, K.C.S.I., "The Rationale of Indian Railways." The MARQUIS OF RIPON, K.G., will preside.

[This meeting has been postponed from May 22, as previously announced.]

CANTOR LECTURES.

Monday evening, at Eight o'clock:—

RICHARD BANNISTER, "Sugar, Tea, Coffee, and Cocoa, their Origin, Preparation, and Uses." Four Lectures.

LECTURE IV. — MAY 19 — *Cocoa*—History—Origin—Preparation for market and consumption—Composition—Commercial cocoas, nibs, soluble, extracts — Chocolate and chocolate creams — Chart showing consumption of sugar, coffee, tea, and cocoa —Specimens of cocoa, chocolate, and creams.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MAY 19...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Richard Bannister, "Sugar, Tea, Coffee, and Cocoa, their Origin, Preparation, and Uses." (Lecture IV.)

British Architects, 9, Conduit-street, W., 8 p.m. Mr. Frank Granger, "German Technical Museums."

Asiatic, 22, Albemarle-street, W., 4 p.m. Anniversary.

Victoria Institute, 1A, Adelphi-terrace, W.C., 8 p.m. Paper on "Flint Implements and the Antiquity of Man."

East India Association, Westminster Town-hall, S.W., 3 p.m. Mr. Herbert J. Reynolds, "A Hundred Years After; or, some Results of the Permanent Settlement."

TUESDAY, MAY 20...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Foreign and Colonial Section.) Mr. Lasenby Liberty, "The Industrial Arts of Japan."

Royal Institution, Albemarle-street, W., 3 p.m. Mr. L. Fagan, "The Art of Engraving." (Lecture III.) "Mezzotint Engraving."

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Messrs. Fawcus and Cowan, "The Keswick Water-power Electric Light Station."

Statistical, School of Mines, Jermyn-street, S.W., 7¾ p.m.

Pathological, 20, Hanover-square, W., 8½ p.m.

Zoological, 3, Hanover-square, W., 8½ p.m. 1. Sir Edward Newton, "The reported Discovery of Dodo's Bones in a Cavern in Mauritius." 2. Mr. P. L. Sclater, "A new Toucan of the Genus *Pteroglossus*." 3. Mr. R. Lydekker, "The Remains of some large Extinct Birds from the Cavern Deposits of Malta." 4. Dr. Hans Gadow, "Description of the Modifications of certain Organs which seem to be Illustrations of the Inheritance of Acquired Characters in Mammals and Birds."

WEDNESDAY, MAY 21...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. J. G. Gordon, "The Mannesmann Process for making Seamless Tubes."

Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Mr. W. B. Tripp, "Rainfall of the Globe — Comparative, Chronological." 2. Mr. W. H. Dines, "Mutual influence of two Pressure Plates upon each other, and comparison of the two Pressures upon small and large Plates." 3. Mr. W. H. Dines, "The variations of Pressure caused by the wind blowing across the mouth of a Tube."

Geological, Burlington-house, W., 8 p.m.

Microscopical, 20, Hanover-square, W., 8 p.m. E. M. Nelson, "Micrometric measurements with the Microscope"

Pharmaceutical, 17, Bloomsbury-square, W.C., 11 a.m. Annual Meeting.

Archæological Association, 32, Sackville-street, W., 8 p.m.

Cleveland Institution of Engineers, Middlesbrough, Yorkshire, 7½ p.m.

Inventors' Institute, 27, Chancery-lane, W.C., 8 p.m.

THURSDAY, MAY 22...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Professor Dewar, "Flame and Explosives." (Lecture III.)

Electrical Engineers, 25, Great George-street, S.W., 8 p.m.

FRIDAY, MAY 23...United Service Inst., Whitehall-yard, S.W., 3 p.m. Major J. C. Ker Fox, "The Training of the German Cavalry in comparison with that of the English."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Prof. A. C. Haddon, "The Manners and Customs of the Torres Straits Islanders."

Clinical, 20, Hanover-square, W., 8½ p.m.

SATURDAY, MAY 24...Royal Institution, Albemarle-street, W., 3 p.m. Dr. C. Waldstein, "Recent Excavations in Greece" (Lecture III.)

Linnean, Burlington-house, W., 3 p.m. Election of Council and Officers."

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FRIDAY, MAY 23. 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

The Society's *conversazione* will take place at the Natural History Museum, Cromwell-road, S.W. (by permission of the Trustees of the British Museum), on Friday, 27th June.

The reception by the Duke of Abercorn (Chairman), and the members of the Council of the Society, will commence at 9.0 p.m.

The following portions of the Museum will be open:—On the Ground Floor—the Central Hall, British Saloon, Bird Gallery, and a portion of the Gallery of Fossil Mammalia; on the First Floor—the East and West Corridors, and the Lecture Room.

The bands of the Grenadier Guards and the Scots Guards will perform during the evening.

Each member is entitled to a card for himself (which will not be transferable), and a card for a lady. In addition to this, a limited number of tickets will be sold to members of the Society, or to persons introduced by a member, at the price of 5s. each if purchased before the 14th June. After that date the price will be 7s.; on the 27th June, 10s.

These tickets can now be purchased. They will only be supplied to persons presenting members' vouchers (which can be obtained from the Secretary) or a letter of introduction from a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter a remittance must be enclosed. Each ticket will admit one person, either lady or gentleman.

Light refreshments (tea, coffee, ices, claret cup, &c.) will be supplied.

As the number of tickets which can be issued is limited, early application is desirable.

CANTOR LECTURES.

Mr. R. Bannister delivered the fourth and last lecture of the course on "Sugar, Tea, Coffee, and Cocoa," on Monday evening, 19th inst.

At the conclusion of the lecture Mr. Bannister expressed his best thanks to Messrs. Appleton and Mackin, Budgett, Cadbury, Fortnum and Mason, Fothergill, Fry, Holborne, Jeffreyes, Lazenby, Mansfield, and Martineau for samples and valuable information; to the Statistical Society and Mr. Busfield for special help, and to his two friends of the Inland Revenue Laboratory, Messrs. Cheater and Richardson, for the valuable assistance they rendered him in preparing diagrams, arranging the samples, &c.

A cordial vote of thanks to the lecturer was passed, on the motion of the Chairman.

ADDITIONAL LECTURES.

The third and last lecture of the course on "Design applied to Wood-Carving," was delivered on Thursday evening, 15th inst.

On the motion of the Chairman, a cordial vote of thanks was accorded to the lecturer.

These lectures will be printed in the *Journal* during the autumn recess.

Proceedings of the Society.

TWENTY-SECOND ORDINARY MEETING.

Wednesday, May 21, 1890; Sir Frederick Bramwell, Bart., D.C.L, F.R.S., Deputy-Chairman of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Hall, Captain Robert Gresley, 60, Avenue-road, Regent's-park, N.W., and 22, Commercial Salerooms, E.C.
Macdonald, General John, 31, Lansdowne-crescent, Cheltenham.
Maclear, Captain John Pearse, R.N., Cranleigh, Guildford, Surrey.
Saillard, Philip, 87, Aldersgate-street, E.C.

The following candidates were balloted for and duly elected members of the Society:—

Gover, Henry, 3, Adelaide-place, E.C.
Greenwell, George Clementson, jun., Poynton, Cheshire.

The paper read was—

THE MANNESMANN PROCESS FOR MAKING SEAMLESS TUBES.

By J. G. Gordon.

A great philosopher has said that the consumption of soap in a country is the measure of the degree of civilisation attained by its inhabitants.

When we consider the ever-increasing variety of uses to which tubes and pipes are now put, it seems to me that it would be equally true to say that the quantity of tubes manufactured and used in any given country serve as a good measure of that country's progress in civilisation.

For the conveyance of water, gas, oil, and steam, for warming and ventilating dwellings and other buildings, and in the construction of all sorts of engines and boilers, as well as for the transmission of power by means of water or air, and last, but not least, for the construction of all sorts of fire-arms, from the 110-ton gun to Colt's derenger, tubes are indispensable; while at the same time engineers are turning more and more attention to tubular form for many parts of structures as they pre-eminently combine lightness with strength.

Before the beginning of this century the use of tubes was comparatively small. Apart from conduits for water, which were generally made of tree trunks with a hole bored through them, as some recently dug up in Harley-street show, when they were made in the form of pipes at all, the main use of tubes, or more strictly speaking, of metallic tubes, was for parts of firearms.

It appears that cast-iron pipes were first cast about the year 1780, I believe at Coalbrookdale Iron Works, and the manufacture has gone on increasing ever since; the consumption of this kind of tube in the United Kingdom alone must be something enormous, considering that there is no town or village where gas and waterworks exist that has not at least two lines of such pipes lying below every street.

Murdoch's great invention, illuminating gas, seems to have given the first impulse towards the manufacture of wrought-iron tubes on a large scale, as they were necessary for the distribution of the gas from the mains to the houses, &c.

At first, rejected gun-barrels, connected together by ferrules, were used for this purpose, but the manufacturers soon devoted their attention to supplying tubes in longer lengths, and from about the year 1808, when Benjamin Cooke took out a patent, more and more attention has been devoted to the perfecting of the machinery for their manufacture, and the materials of which they are made.

The process of manufacture of welded wrought iron and steel tubes consists first in making a strip of metal of the length of the tube required, and rather wider than the circumference of the tube required. This strip of metal is heated to a welding heat, and then bent by machinery into a tubular form. It is then welded either by means of hammers, by drawing through a die, or by being passed between rolls of appropriate section, and much skill and ingenuity have been devoted to the perfecting all the details of this complicated and difficult process, with the result that now such wrought iron or steel tubes can be obtained in almost any quantities, and at prices which, compared to those which were formerly paid, are very moderate. But although the wrought iron and steel welded tubes are both cheap and good, they had, and still have, a weak point—namely, the weld. It is here that they are generally found to give way under any severe strain, besides which, above and below certain diameters—that is, below about one inch and above about six or seven inches—the difficulties of the manufacture of welded tubes are much increased. This difficulty in making tubes of large diameter has been overcome, to some extent, by rivetting together plates bent into a tubular form, but this is necessarily a costly process, and considerable difficulty is experienced in making the rivetted joints perfectly tight It has therefore been the aim of many inventors for the last thirty or forty years to produce weldless or seamless steel and iron tubes, and a considerable number of processes for producing such tubes have been devised, and many patented in this and other countries, by means of some of which at the present time considerable quantities of weldless tubes of high quality are being produced. The Mannesmann process, the subject of the paper I have the honour of bringing before you this evening, is one of these latter processes. It has already been described in a paper by Mr. F. Siemens, read before the British Association at their Bath meeting in 1888, in which that gentleman pointed out the salient features of the new process.

The Messrs. Mannesmann produce weldless or seamless tubes of steel, or any other ductile metal, such as copper, bronze, delta metal, lead, or aluminium, by rolling them in skew-rolls; that is to say, in rolls which are not parallel either to one another, or to the bar or other material to be treated by them. Perhaps the photographs will make this clearer than any verbal explanation.

Here a photograph of ordinary rolls parallel to each other was shown, and then a photograph of Mannesmann rolls.

It will be seen that, in the ordinary rolls, the bar to be rolled is put in at right angles to the rolls, which revolve in opposite directions. But in the Mannesmann tube-mill both rolls revolve in the same direction, and the bar to be acted upon is placed between them lengthways, while, as before mentioned, the axes of the rolls are not parallel to one another. In the photograph on the screen, these are the rolls, and the tube in front of them acts as a guide for the bar, which is pushed in between them.

These rolls revolve at about 200 to 300 revolutions per minute, and by their action on the hot and therefore plastic steel, stretch it, and make a hollow in the centre.

To explain why the rolls acting in this peculiar manner have the effect on the bar of steel subjected to their action of converting it into a tube, I cannot do better than to quote from the paper by Mr. Frederick Siemens already alluded to. He says :—

"To obtain a simple forward spiral action of the bar, the length of the rolls is immaterial; it will take place when the rolls are reduced to the form of thin discs. Supposing the discs to be infinitely thin, or what is the same thing, that their outer edges are reduced to a mathematical line and no sliding motion takes place, the bar must still move forward spirally, its spiral velocity being equal to the velocity of the outer circumference of the discs. If, instead of one pair of such thin discs, several pairs of discs of regularly increasing diameters are made to revolve on the same axis, the outer circumference of each disc will revolve with greater velocity than that of the preceding one. The same bar is, however, drawn forward through the several pairs of discs, and thus as each part of the bar enters successively a more advanced pair of discs, the velocity with which that portion of the bar rotates increases, and it is drawn forward by each succeeding pair of discs as they catch hold of it with ever-increasing speed.

"It will be understood that a bar passing through such a series of discs, no slipping being possible, the material of which it is composed cannot retain its original area or volume. The diameter of the bar being regulated by the discs, while simultaneously a violent stretching action is carried on, the material required can only be drawn from the inside of the bar, and thus a hollow space is formed.

"Instead of this peculiar arrangement of discs a conical, or rather conoidal, pair of rolls, which amount to the same thing as the discs, considered as joined together, may be provided. It follows that a bar or rod of suitable dimensions which is passed through the Mannesmann rolls will, provided its substance is sufficiently homogeneous and plastic, undergo a violent twisting and stretching action, the fibre being spun as is the fibre in a rope, on account of which the process may appropriately be called a tortional process. The bar in its passage through the rolls is twisted as a thread is twisted in a spinning-machine. As, however, it cannot be fed from the outside as is the thread, and, as has been said, the diameter cannot be reduced on account of the action of the rolls, it is forced to draw on the interior for a supply of material.

"I will attempt to explain in another way.

"The tube is made thus. A bar is placed between the conoidal rolls at the part where their diameter being least the speed at which they move to make a revolution is also least. The rolls seize the bar and draw it into contact with parts of the cones which move more and more rapidly, though, owing to the way in which the rolls are set, the space left between them for the passage of the bar decreases slightly. Slight, however, as is this decrease in the space between the rolls, a certain amount of material has to be shifted. The action of the rolls prevents this material from being taken from the outside of the bar, and consequently it is drawn from the interior—hence the tube. Soon after entering the rolls a small central fracture is formed, which widens out to a hollow space as the increased stretch is made to take effect in an increased twist acted on from the surface.

"The increasing twist of the fibre of the bar while passing through the rolls, and the peculiar relation kept up between longitudinal and turning action, is the characteristic of the Mannesmann tube-rolling machine, and this action it is that enables it to make a tube from a solid bar or ingot.

"Though the bar is thus converted into a tube by the action of the rolls, and their action only, a mandril is generally used to finish and smooth the interior and enlarge the tube. This use of the mandril has led to the erroneous belief that it is necessary to form the hole in the bar. No machine, however, could stand the strain if it were attempted to force a mandrill longitudinally through a solid bar of hot steel. Such an operation is impossible. Just sufficient power is used to form the hollow in the bar from the action of the rolls on the outside, and into this hollow the mandril enters, smoothes the inside, and, when required, enlarges the tube. Thus we have the strange experience in rolling that by one operation the bar is made hollow and also longer and wider than when it entered the rolls a few seconds before."

Here is a tube, or rather hollow bar, manufactured by the Mannesmann process, which shows that the mandril mentioned by Mr. Siemens takes no part in the process of making the hole, or in other words, converting the solid round bar into a tube.

Before being passed through the Mannesmann rolls the ends of this bar were slightly drawn down under the hammer, so that for about an inch and a half at both ends its diameter was decreased so that the rolls could not act on them. After being passed through the rolls the bar was broken in the middle, and, as you see, a tube had been formed from the solid bar along all that part of its length on which the rolls acted, while both ends remained solid. A hollow produced thus in a massive steel bar should be a perfect vacuum. In order to test this, Messrs. Mannesmann sent several such tubes with closed ends to Professor Finke, in Berlin, who devised a most ingenious apparatus for testing both the pressure in the interior of the tube, and also the chemical composition of the gases, if any, contained therein. As the average result of several experiments he found that the pressure in the tube was as nearly as possible one-tenth of an atmosphere, and that the gas which the hollow did contain consisted of 99 per cent. of hydrogen, and he considers it most probable that the other one per cent. was nitrogen.

Here are some photographs taken at the Mannesmann Tube Company's works. This is a photograph of the largest Mannesmann mill as yet erected, and which has produced all the large tubes you see before you.

This is the mill, these are the steam-engines, and here is the large fly-wheel, this is a very valuable aid in the process. The power required to produce the tubes is very large, something like from 2,000 to 10,000 horse-power, according to the dimensions of the tube. If a steam-engine of this power had to be provided for each machine, the plant would of course become extremely costly, but, luckily, this great power is only required for a short time; for each tube made 30 to 45 seconds suffice to convert a bar 10 to 12 feet long, and 4 inches in diameter, into a tube, and then some time elapses while the next bar is brought up, adjusted in the guides and the finished tube removed. During this time it is possible to accumulate energy in the fly-wheel, and by this means a comparatively small steam-engine of about 1,200 horse-power is quite sufficient to do the work.

The fly-wheel differs materially in construction from those ordinarily in use, and was designed by Messrs. Mannesmann to guard against the terrible danger of bursting, to which accident cast-iron fly-wheels are only too subject when worked at a high speed. This wheel consists of a cast-iron hub, to which are securely bolted two discs of steel plates of about 20 feet in diameter: round the periphery of the wheel thus formed about 70 tons of No. 5 gauge wire are wound under a tension of about 50 lbs., thus binding the whole securely together. There can be no comparison between the resistance of a wheel so constructed to the centrifugal force and that offered to this force by a cast-iron one. This fly-wheel, of 20 feet in diameter and weighing 70 tons, revolves 240 times per minute; therefore, the periphery of the wheel has a speed of 2·85 miles per minute, or nearly three times the speed of the "Flying Dutchman." This fly-wheel works on the main shaft from which the tube mill is driven by means of helical-toothed steel wheels.

Behind the steam-engine are the doors of the heating furnace—it is a Siemens regenerative furnace, heated by radiation—the only thing which distinguishes it being its great size; it is 33 feet long by 21 feet wide, and has an area of 789 square feet.

The small steam-engine near the rolls is used for adjusting them.

It is one of the many distinctive features of the Mannesmann process that much greater accuracy is required in the adjustment of the rolls than was hitherto dreamed of in the philosophy of iron and steel millwrights. Hitherto, even such delicate work as rolling fine wire rods, and thin sheets for tinning and stamping, has been accomplished by machinery, comparatively speaking, of the roughest description, in which the skill of the rollerman and roll-turner had to make up for the inaccurate fitting and adjustment of the rolls. But in the Mannesmann mills every part is as carefully and accurately fitted as in a locomotive or marine engine, and the screws and balances are designed to, and do, enable the foreman roller to adjust the rolls to the 1-32nd of an inch.

The photograph now on the screen is a smaller Mannesmann tube mill already shown when describing the process; there are here two smaller wire flywheels, one to each of the rolls.

After the tubes have been rolled, it is generally necessary to cut screws on the ends, as this is the usual way of connecting steel and wrought-iron tubes together, for making them into gas or water mains, and other similar purposes.

Here is a photograph of the screwing machines at Landore; there are twelve of them; they are made to cut screws on tubes of any diameter, from 2 inches up to 12 inches. The screws cut by these machines are known as the American tapered thread screws. To make these the machines, instead of cutting the screw to a uniform depth, begin by making a deep cut which slightly diminishes with every turn, so that the end of the tube becomes slightly conical. This is an improvement on the ordinary straight thread, as every turn makes the socket fit tighter on to the tube, while when it is wanted to unscrew the tube it is more easily released.

Here is a pile of tubes finished and ready for inspection.

The three next slides are photographs of the tubes which have been tested under compression, and which are here before you.

These Tables give the results. The first and second series are Mannesmann tubes, the third are lap-welded wrought-iron tubes, which have been tested by way of comparison.

TABLE I.—Steel Tubes.

External diameter of the tubes before turning .. 4½ in.
Length over all .... 1 ft. 5½ in.
Length between shoulders .... 10 in.

	External diameter.	Internal diameter.	Thickness.	Area.	Ultimate strength.	
	inches.	inches.	inches.	square inches.	tons per sq. inch.	
A	4·45	4·36	·045	·622	20·9	Note.—The testing machine was not strong enough to have any effect on tube D.
B	4·47	4·33	·07	·939	25·53	
C	4·5	4·31	·095	1·315	27·7	
D	4·565	4·325	·12	1·666	—	

A strip cut parallel to the axis of a tube, similar to those used in the above tests, gave the following results when tested:—

Breaking strain per sq. in., 35 tons; elongation in 8 ins., 25 per cent.; contraction of area, 54·2 per cent.

TABLE II.—Steel Tubes.

External diameter before turning .... 3½ in.
Lengths over all.............................. 1 ft. 5½ in.
Length between shoulders .... 10 in.

	External diameter.	Internal diameter.	Thickness.	Area.	Ultimate strength.	
	inches.	inches.	inches.	square inches.	tons per sq. inch	
A	3·31	3·2	·055	·600	18·6	B, C, and D of this set failed without fracture.
B	3·3	3·18	·06	·611	25·3	
C	3·36	3·19	·085	·871	28	
D	3·29	3·03	·13	1·10	34·9	

A strip cut parallel to the axis of a tube, similar to those used in the above tests, gave the following results when tested in tension:—

Breaking strain per sq. in. 37 tons; elongation 20 per cent. in 8 ins.; contraction of area 42·5 per cent.

TABLE III.—WROUGHT-IRON TUBES.

External diameter of tubes before turning ...... 3⅞ in.
Length over all .... 1 ft. 5½ in.
Length between shoulders .... 10 in.

	External Diameter.	Internal Diameter.	Thickness.	Area.	Ultimate Strength.
	Inches.	Inches.	Inches.	square inch.	tons per sq. in.
A	3·63	3·55	·035	·399	17·54
B	3·7	3·56	·07	·802	18·08
C	3·73	3·53	·10	1·14	19·98
D	3·78	3·54	·12	1·38	20 9

Of course it requires a larger series of tests than these to be able to deduce many definite conclusions from them, but they go to show that under compression these tubes stand better than the welded ones, and that when they give way they do not break, but only bend. These large specimens are too heavy to be handed round, but there are some smaller ones which show that even when the tubes are completely crumpled up they do not burst or crack.

These tests under compression were made to show the value of the Mannesmann tubes for use in all sorts of engineering construction, and the results are satisfactory as far as they go. At the company's works there are at present no means for testing long lengths of tubes under compression, but the company hope soon to have such tests made for them.

What mainly distinguishes the tubes made by the Mannesmann process from all weldless tubes hitherto made is, first, that they are made from bars of solid steel or other metal into tubes without any preliminary boring of the material; and, secondly, that the fibre of the metal runs spirally round the tube when made.

In all other processes for making weldless or seamless tubes the material is either cast in the form of a cylindrical ingot with a hole down its centre, or the metal, after having been cast, forged, or rolled into the form of a cylinder, has a hole bored through its centre. The hollow cylinder, whether cast or bored, is then drawn through a series of gradually diminishing dies, and over an appropriately-shaped mandril, on a draw-bench similar to those employed in wire drawing. This, of course, necessitates frequent annealing of the material, as otherwise it would soon become brittle.

These successive drawings tend to produce a longitudinal fibre in the metal, just as the ordinary rolling of iron and steel bars and strips does, and such a longitudinal fibre necessarily tends to make the tube weaker, especially as regards internal pressure, than the Mannesmann tubes with a spiral fibre, the quality of the metal and all other conditions being the same in both tubes.

That a spiral fibre has long been regarded as a source of strength is shown by the method adopted by gunsmiths for making shot-guns of good quality. As is well known, these are made by welding together the best quality of scrap iron, such as horseshoe nails. These are carefully made into small rectangular rods, which are then coiled round a mandril and welded together, and thus forming a spiral fibre. A collection showing this process in all its stages, from the packet of scrap iron to the finished gun barrel, is exhibited in the Museum of Practical Geology, Jermyn-street. On a large scale this process is used by Lord Armstrong for making the wrought-iron coils for his celebrated guns.

For purposes of comparison I have here two small bottles made out of a Mannesmann tube and a lap-welded boiler tube respectively. These have been filled with boiled water, and placed in a freezing mixture. The expansion which takes place on the solidification of water to ice exerted sufficient force to burst the lap-welded tube, but you see that the Mannesmann tube withstands this great pressure. Here are a pair of similar tubes; the one with the white paint on it is the Mannesmann tube. You will see that the welded tube has split in the direction of the longitudinal fibre from end to end. This small tube has also withstood a severe test. It is an inch in internal diameter, and about 3-64ths of an inch in thickness. This was subjected to an internal pressure of 3 tons 15 cwts. to the square inch, at Messrs. Siemens Bros. works at Charlton, when the leather washer closing one of the ends gave way. When taken out the tube was distinctly warm to the touch, but otherwise exactly the same as before the test was applied. This pressure of 3 tons 15 cwts. per square inch is equal to a tensile strain on the metal of over 70 tons per square inch.

The power of resisting great internal pressure makes the tubes particularly well adapted for vessels made to contain gases at high pressures, such as oxygen and carbonic acid, which are now being largely used in the arts, and it may also serve to extend the use of compressed air, a subject to which our Chairman has devoted much attention.

Unfortunately, the tube testing machines have only just been delivered at the Landore works of the Mannesmann Tube Company, so that no other tubes which have been tested to very high pressures can be put before you, but at the Austrian Mannesmann Works, at Komotan, more than 600 tons, or twenty-five miles of four-inch, and three-inch tubes about quarter inch thick, have been tested to a pressure of 2,000 pounds per square inch, and passed by Mr. E. Woods, inspector. These tubes have been sent to Chili; they are intended for a high pressure water main for pumping water up to the rainless nitrate deposits.

But the severest test which the Mannesmann tube can possibly be subjected to is the process of manufacture itself. If the metal is homogeneous throughout, and well melted, well rolled, and carefully heated, it makes, as you see, a perfect tube, or, at any rate. a near approach to it; but if there is any flaw in the bar, or if the furnace man has been careless in the heating, then the Mannesmann rolls reject that bar, by refusing to make a tube of it, more sternly than the severest human inspector would. This process is, in fact, so far as regards what is called humouring the metal, to the ordinary rolling process, what the tilt-hammer is to the late Mr. Nasmyth's steam-hammer, so that every tube made by this process comes into the world ready tested.

These are specimens of the tubes subjected to various tests, both hot and cold, and of various dimensions; most of them are too heavy to be handed round, so as some of the audience may perhaps wish to inspect them more closely, the Society of Arts have kindly allowed them to remain on view in the library, downstairs, until next Tuesday.

As to the uses to which the tubes can be put, they can be used for all purposes for which tubes are now used; for water-pipes, especially where water has to be carried long distances at high pressure, they are already being largely applied.

Table IV. (p. 654) shows the comparative weights per foot and per mile of cast-iron pipes and Mannesmann tubes. It is obvious that wherever such pipes have to be transported long distances from the place of manufacture to the place where they are to be used, what a great advantage the saving in the weight to be carried will be, more especially in cases, like in South Africa and Australia, where railway transport is not often available.

Further, their lightness and the greater lengths to which they can be made, will effect a large saving in the cost of labour in laying them down and in the cost of the joints, both of which form a serious item in the cost of any pipe line. What has been said of water applies equally to petroleum and to gas and steam.

Another advantage of the Mannesmann tubes, for the purposes alluded to, is that they are capable of resisting much higher internal pressure in comparison to the thickness of their shells, or, in other words, of their weight per foot. While cast-iron pipes will hardly stand more than two hundred pounds per square inch, and welded tubes are not as a rule safe above 1,000 lbs. per square inch, the Mannesmann easily withstand 2,000 lbs. per square inch.

The length up to which these tubes can be easily made is shown by this coil made of a tube three inches in internal diameter, and about quarter of an inch thick, by seventy feet long; it weighs about 6½ cwt.

Hollow axles for railway and other waggons, especially for field-gun carriages and ammunition and other waggons, hollow shafts and poles for carriages, can be readily made from these tubes, as well as gun barrels and gun tubes, and shells. The Prussian Government have already given the German Mannesmann works large orders for military stores of various kinds, or rather, for the tubes from which to make them; for instance, the lances with which the whole of the German cavalry are about to be armed are to be made of Mannesmann tubes, and are already in course of manufacture. Three of them are among this group of Mannesmann tubes

TABLE IV.

Cast-iron Pipes.			Steel Tubes.		
Internal diameter.	Weight per foot.	Weight per miles.	Internal diameter.	Weight per foot.	Weight per miles.
	lbs.	tons.		lbs.	tons.
3	13·5	31·8	3	6·2	14·6
4	18·6	43·8	4	8·2	19·3
5	24·5	58·4	5	10·1	23·8
6	31·1	73·3	6	12·1	28·5
7	37·3	87·9	7	14·1	33·2
8	45·0	106·0	8	16·0	37·7
9	52·9	124·7	9	18·0	42·4
10	62·0	146·1	10	20·0	47·1
12	74·5	175·6	12	25·0	58·6
18	140·0	330·0	*18	46·8	110·1

recently shown at Berlin, when Professor Reuleaux read a paper on the subject of the tubes before the Berlin Society of Engineers, which will doubtless be published ere long. The German daily papers of all shades of opinion have already published long notices of this paper, not only because of Professor Reuleaux's great reputation, but more especially because they are justly proud that the world should be indebted to Germany for such an important invention, which will no doubt in the future be reckoned among those decided steps in advance which the arts, which it is the aim of this Society to cultivate and encourage, make from time to time.

Messrs. Reinhard and Max Mannesmann, the inventors of the process, are the sons of Mr. Reinhard Mannesmann, file and steel manufacturer in Remsheid, which has for centuries been, in conjunction with the neighbouring town of Solingen, what Sheffield and Birmingham are to England.

More than thirty years ago Mr. Mannesmann, senior, tried to manufacture steel rifle barrels by rolling down carefully-cast hollow steel ingots, but did not succeed in getting sufficiently uniform results to proceed further than the experimental stage; but he never quite gave up the idea, and when his two eldest sons left the university he told them of his experiments. They took them up, and brought the training which they got at German universities, as well as their own indomitable perseverance, energy, and determination, to bear on this problem, and have, after years of hard work, succeeded in constructing the machines and devising the process, the results of which you see before you.

At present there are five works making, or about to make, tubes by this process.

First, the parent works at Remsheid in Rhenish Prussia, where all the early experiments were carried out; then another works in South Germany, at Bous, near Saarbrücken; the Austrian works at Komotau; a works near Duisburg, which is being specially erected for making tubes of copper and its alloys; and lastly, the works at Landore, near Swansea, belonging to the Mannesmann Tube Company, who have acquired Messrs. Mannesmann's English patent rights. At these works, which are under the management of Mr. Charles Mannesmann, a brother of the inventors, three Mannesmann mills are now at work, and two more are in course of erection, so that the works will soon be in a position to turn out large quantities of seamless steel tubes of all sizes from 1 inch up to 16 inches in diameter, various specimens of which you see before you.

In conclusion, I wish to say that I am indebted to Mr. Charles Mannesmann and Mr.

Pfau, the chief engineer at Landore, for the trouble they have taken in making the beautiful collection of samples I have had the honour of showing you this evening, and also to thank Mr. Mostyn Clarke, who has prepared all the slides shown this evening from photographs taken by himself, and who has carried out the greater part of the tests submitted to you at the test-house at Landore, of which he has the superintendence.

DISCUSSION.

The CHAIRMAN said the subject was no doubt an important one. He did not know whether they would go the length of saying that civilisation was to be gauged by the feet-run of tubes used in twelve months, but, nevertheless, the quantity used was a fair indication of enterprise and industry. Latterly a good deal had been done to supersede tubes altogether, by using wires as a means of conveying energy in the form of electricity, but water must still be sent through tubes, and any process which tended to produce the article more cheaply or better was one well worthy the attention of the Society of Arts. In 1888 he had the pleasure of hearing Mr. Frederick Siemens's paper at Bath on the subject, and it then occurred to him that probably this was about as extraordinary a method of arriving at the desired product as could well be imagined. The result of putting a solid circular bar of steel in between a pair of skew rolls was to cause it to change itself into a tube. This seemed to be very extraordinary, and although one knew it was done, he found great difficulty in bringing home to his mind how it was done, and he had, almost in vain, endeavoured to put it before himself in an intelligible way. The only way in which he could explain the result was somewhat as follows:—Supposing he had a solid circular stick of putty, and he held that putty in his left hand at one end, and he took his right hand and drew the putty endways, if he held the putty pretty firmly the probability was that he would succeed in drawing out a sort of skin, which would come beyond the end of the solid putty, and so leave a cavity. One might have hold of a material, letting it go only gradually, while causing the outside to go forward at a greater pace, and in that way, by perpetually drawing forward the outward coating, you might succeed in converting a solid bar into a tube. He should have thought it would have been a most hopeless problem for any man to set himself to make seamless tubes in that manner, and it was difficult to imagine how the process was arrived at originally. Mr. Gordon had spoken of the great strength of the tubes, owing to the fibre being in a spiral direction, as in gun barrels, but it struck him that the metal must be subjected to enormous torsion, though the result appeared to be a satisfactory tube. The most striking specimen, and one which made it clear that no perforation by a mandril was needed, was the tube that was made out of a solid bar of which the two ends were somewhat reduced, so that the rolls did not operate upon them, and, therefore, there was formed in the bar itself a concealed tube with closed ends. That appeared to be an extraordinary illustration of the working of the process. It was obvious to his mind that one could succeed in making a tube which for such purposes as the storage of gases was absolutely faultless, as there was no joint in it from beginning to end. He thought they ought to be glad that the manufacture had been established on so large a scale, and one could only wish it every success.

Mr. A. B. W. KENNEDY, F.R.S., could not conceive any process more puzzling than the manufacture of a hollow tube from a solid bar, and it had been a great pleasure to him to hear the description of a process of such extraordinary difficulty brought to such a high state of practical perfection. The results of the tests were extremely good, taking into consideration the extreme thinness of the tubes operated upon, and the fact that the internal tube was by no means accurately finished in any way. The outside might be turned down, but the inside must be irregular, all of which irregularities would tend to weaken the tube; but in spite of this they had stood the test of compression.

The CHAIRMAN asked whether the 70-feet tube with a 3-inch bore had been produced from a solid bar in the rolls or drawn out on a draw-bench, and what length of bar was used to produce the 70 feet.

Mr. GORDON replied that it had not been drawn out in any way; it had been produced in several operations, but it was all done by rolling of that character, and was finished in the ordinary straight roll. The original bar was about 12 feet long, and it took four or five operations to produce the tube.

Mr. ALEXANDER SIEMENS said some experiments had been made at the Charlton works to test the strength of the tubes, and although hydraulic pressure of three tons to the square inch had been used, they had not succeeded in breaking the pipes. It was evident that the tubes would lend themselves to a number of purposes; and as he understood they could be produced more cheaply than tubes in the ordinary way, he thought there was a great future before them. He quite agreed with the remarks made by the Chairman that the process was a most extraordinary one.

Mr. J. C. CHAPLIN said he should be glad to have some further information as to the method of working, for it seemed to him like turning a piece of metal inside out.

Mr. A. L. JONES said when listening to the way in which the tubes behaved themselves under internal pressure, he was struck by the analogy between them and copper tubes made by the Elmore process. He had seen a Mannesmann tube tested by internal pressure which swelled 50 per cent. in diameter, and an Elmore copper tube tested in the same way gave exactly similar results. He thought this pointed to a circumferential grain, like that in the Elmore copper tube. He should like to know what effect any inaccuracy in the adjusting of the rolls had on the central position of the hole, because it struck him that any inaccuracy would have the effect of making the hole eccentric, and so impair the utility of the tube.

Mr. GORDON said if it was a difficult process to understand, it was still more difficult to describe. It looked very simple when one saw it done, so did a conjuring trick, but it was a very difficult thing to say how it was done. As Mr. Chaplin had stated, it very much resembled the drawing of the material of the outside of the tube over the inside. He might say that yesterday he received from Germany a shorthand note of Professor Reuleaux's lecture on the subject, from which it appeared he used exactly the same simile, for he said it was like taking a fox's skin over his ears. As he understood it, the *modus operandi* was this—that while the grooved rolls were rotating at a high rate of speed, they tended to force the outer part of the metal forward, while the grip with the part of the rolls which was close together tended to retard the flow of the whole of the metal. The grooves pushed forward the outside of the metal, which was plastic, being of course at a high temperature, while by the grip of the roll the inner part was retarded, and thus formed into a cup shape, and consequently into a tube. In making tubes of a large diameter, the operation was greatly facilitated by the mandril, as it helped to retard the flow of the metal.

The CHAIRMAN asked whether the mandril was allowed to rotate.

Mr. GORDON—Certainly. The rolls need not necessarily be of the shape which he had shown in the photograph, but might be discs.

Mr. F. W. FLETCHER said if metal (especially metals like soft steel) were rolled, there was a tendency for it to run with the rollers. The natural tendency was to follow the shape and direction of the rollers. At the Royal Institution, two or three years ago, Professor Roberts-Austen, when lecturing on metals and alloys, gave several illustrations proving the fact that rolled metals had an external tension. He thought the reason the metal formed itself into a tube was to be accounted for by the speed of the rollers.

The CHAIRMAN, by way of further explaining the possible action of the rollers, suggested that if four rolls were arranged so as to grip the rod on all four sides, while the rod was also held by four similar rolls running at a lower speed, it seemed to be clear that the grip of the bar of the front rolls would be resisted by the lesser speed of the back rolls, and the only way in which the two differences could accommodate themselves to one another was that the outer skin of the metal would be dragged forward as a sort of tube, just as the sleeve of the coat would be drawn off the arm if you passed your hand down along it. In conclusion, he begged to propose a hearty vote of thanks to Mr. Gordon for his interesting and instructive paper.

The vote was unanimously passed.

The CHAIRMAN—Before dissolving the meeting there is one thing which I must bring to your notice. Our Secretary, Mr. H. Trueman Wood—shortly to be Sir Henry Trueman Wood—is put forward for a mark of honour from our Sovereign, which I am sure no man has more thoroughly deserved than he has. The way in which he has carried out the duties of Secretary since the death of Mr. Le Neve Foster, must, I am sure, have been appreciated by our thousands of members, and the way in which he carried on those duties which he undertook of looking after British industries at the late Paris Exhibition deserves praise at all hands. We, as a Society, must be extremely grateful, indeed, that her Majesty has been pleased to confer on Mr. Wood this honour. I am sure we all offer him our hearty congratulations.

Mr. H. TRUEMAN WOOD—Sir Frederick Bramwell and gentlemen, I think this subject hardly comes within the fair scope of the discussion this evening, but as the Chairman has so kindly referred to the matter, and you have taken it up so warmly, you will, I am sure, allow me to thank you very heartily for the way in which you have received the announcement. The honour, which I deeply appreciate, that her Majesty has been pleased to confer on me, I regard not as due to any merit of my own, but merely as a compliment to the Society, and I hope, also, that it may be of some service to the Society. Further, I hope that it may induce me to render more useful services to the Society, to which I feel I owe so much, than I have been able to do in the past.

FOREIGN & COLONIAL SECTION.

Tuesday, May 23, 1890: Sir GEORGE BIRDWOOD, K.C.I.E., C.S.I., in the chair.

The paper read was on "The Industrial Arts of Japan," by A. LASENBY LIBERTY.

The paper and discussion will be printed in a future number of the *Journal.*

THE DANUBE AND ITS TRADE.

The following Table of Exports from the Sulina mouth of the Danube, intended as an appendix to the paper on "The Danube and its Trade," by Lieut.-General Sir John Stokes, K.C.B. (see *ante* p. 559), has been received from the author: —

PRINCIPAL MERCANTILE EXPORTS FROM THE SULINA MOUTH OF THE DANUBE, FROM THE YEAR 1873 TO 1889 INCLUSIVE.

Description of Goods.	Unit of Measure.	1873.	1874.	1875.	1876.	1877.	1878.
Wheat	quarters....	1,003,281	1,033,943	1,447,990	1,418,651	274,872	950,758
Rye	,, ...	61,006	98,183	126,980	319,361	86,706	164,681
Maize	,, ...	1,071,500	738,565	1,006,836	2,354.323	334,290	2,132,209
Barley	,, ...	1,247,486	1,403,581	892,981	1,239,936	519.056	1,225,358
Oats	,, ...	94,783	259 467	60,306	32,609	13,708	18,651
Beans	,, ...	4,216	1,225	15,260	65,141	4,914	70,939
Millet	,, ...	..	..	..	..	..	..
Rape-seed	,, ...	214.342	59,644	79.397	35,734	10,822	117,612
Linseed	,, ...	..	..	..	..	..	..
Hemp-seed ..	,, ...	..	..	..	..	..	..
Bran	kilogr.	..	..	..	..	..	..
Flour	,, ...	3,004.389	6,112,557	7,651,893	6,499,262	83,520	6,803,666
Repasse	,, ...	..	..	..	..	..	..
Planks	number	774,704	597,294	731,838	705.569	227,873	949,060
Sleepers	,, ...	..	..	..	..	..	..
Staves	,, ...	112,500	..	..	..	.	..
afts	,, ...	..	..	..	..	..	..
Building wood.	cubic metres	..	..	..	..	..	..
Cheese	kilogr. ...	291,447	820,192	1,739,770	274,466	..	396,314
Wine	,, ...	..	..	..	..	..	..
,, ...	barrels	..	..	..	..	..	..
Spirits of wine..	kilogr.	..	..	..	..	..	..
,, ,,	barrels	..	..	..	..	..	..
Alcohol	kilogr. ...	..	..	..	..	..	..
Salt	,, ...	..	..	..	..	..	..
Tar	,, ...	582,810	384,010	257,926	1,372,712	46,500	218,810
Cattle	number	..	18,930	10,764	.	..	2,420
Horses	,, ...	..	..	..	..	..	..
Skins	kilogr.	12,283	..	173,387	..	..	..
,, ...	bales	3,069	3,649	..	..	12	1,985
Laths	number	..	..	..	..	..	..
Pigs..........	,, ...	..	..	..	..	..	..
Wool	kilogr.	..	642,850	..	..	..	84,050
,, ...	bales	2,786	..	3,761	2,025	20	600
Suet	kilogr.	4,851	23,861	27,301	705,976	..	..
Petroleum	,, ...	2,094,589	2,132,833	1,406,866	3,366,472	366,420	655,885
,, ...	barrels	..	..	..	..	..	..
Pipes	number	..	..	..	..	..	..
Tobacco	kilogr.	..	..	..	..	..	..
Bricks	number	..	..	..	..	..	..
Nuts	kilogr.	..	..	..	..	..	..
Butter	,, ...	..	..	..	..	..	..
Sundries	,, ...	..	..	..	..	..	..

PRINCIPAL MERCANTILE EXPORTS FROM THE SULINA MOUTH OF THE DANUBE, FROM THE YEAR 1873 TO 1889 INCLUSIVE—*(Continued).*

Description of Goods.	Unit of Measure.	1879.	1880.	1881.	1882.	1883.	1884.
Wheat	quarters	1,482,273	1,286,253	444,917	942,376	1,329.304	683,683
Rye	,,	242,209	270,049	150,175	375,633	375,999	405,978
Maize	,,	2,640,187	1,215,416	3,528,886	2,656,149	2,331,475	2,537,495
Barley	,,	836,521	1,219,405	1,026,014	2,381,071	1,492,524	620,445
Oats	,,	17,884	117,216	59,584	30,851	16,562	15,717
Beans	,,	70,454	97,043	89,905	112,455	65,905	100,944
Millet	,,	..	..	..	..	..	..
Rape-seed	,,	87,042	29,810	83,027	98,354	33.421	45,122
Linseed	,,	..	..	..	..	..	..
Hemp-seed	,,	..	..	..	..	..	..
Bran	kilogr.	..	..	..	..	..	..
Flour	,,	8,740,062	10,238,936	9.573,066	6,370,043	4,606,847	2,790,252
Repasse	,,	..	..	..	..	..	396,450
Planks	number	758,633	567,933	1,756,252	1,739,028	1,537,397	1,690,353
Sleepers	,,	31,663	19,262	..	..	..	..
Staves	,,	..	..	280,666	..	..	..
Rafts	,,	..	..	..	..	..	..
Building wood.	cubic metres	..	23,065	21,445	19,963	51,407	62,977
Cheese	kilogr.	700,943	1,038,001	469,371	1,047,888	254,014	248,629
Wine	,,	..	1,109,890	58.700	155,000	..	147,017
,,	barrels	..	83	350	866	371	..
Spirits of wine..	kilogr.	..	..	..	..	..	..
,, ,,	barrels	..	..	..	..	..	..
Alcohol	kilogr.	..	..	..	..	..	..
Salt	,,	..	..	..	53,760	45,630	119,730
Tar	,,	294,490	..	372,625	17,960	39,265	117,922
Cattle	number	50	..	..	..	..	..
Horses	,,	..	..	..	..	..	..
Skins	kilogr.	..	..	..	11,429	28,957	234,999
,,	bales	505	347	42	1,316	219	10
Laths	number	1,180,065	4,003.590	..	..	..	..
Pigs	,,	..	..	..	..	..	..
Wool	kilogr.	100,300	265,350	858,858	69,400	317,732	363,195
,,	bales	600	309	..	1,795	999	..
Suet	kilogr.	..	..	..	..	..	..
Petroleum	,,	..	35,000	369,920	..	2,760	..
,,	barrels	..	3,987	..	..	..	..
Pipes	number	417,299	104,000	..	..	..	..
Tobacco	kilogr.	..	..	..	..	..	..
Bricks	number	..	..	..	..	..	..
Nuts	kilogr.	..	..	..	..	..	..
Butter	,,	..	..	..	..	..	..
Sundries	,,	..	..	..	..	..	..

PRINCIPAL MERCANTILE EXPORTS FROM THE SULINA MOUTH OF THE DANUBE, FROM THE YEAR 1873 TO 1889 INCLUSIVE—*(Continued)*.

Description of Goods.	Unit of Measure.	1885.	1886.	1887.	1888.	1889.	Totals for 17 years.
Wheat	quarters	1,427,140	1.348,379	2,462,149	4,018,078	4,607,619	26,161,660
Rye	,,	514,549	517,562	673,427	1,098,747	1,457,682	6,938,927
Maize	,,	2,382,447	2,861,233	3,391,659	2,036,296	2,502,457	35,721,423
Barley	,,	1,193,806	894,564	1,263,137	1,429,981	1,552,742	20,438,608
Oats	,,	266,692	290,946	202,928	271,384	361,047	2,130,335
Beans	,,	96,549	169,946	132,175	77,764	40,585	1,215,420
Millet	,,	..	..	19.370	8,550	23,271	51,191
Rape-seed	,,	145,056	308,324	46,890	214,622	75,089	1,684,308
Linseed	,,	..	..	4.736	12,418	14,365	31,517
Hemp-seed	,,	..	..	6,819	10,995	4,072	21,886
Bran	kilogr.	..	..	..	655,677	460,802	1,116,479
Flour	,,	10,015.977	8,664.534	8,656,472	14.327,017	15,699,653	129,838,346
Repasse	,,	477,985	389,006	1,356,365	3,389.321	1,544,051	7,553,178
Planks	number	1,491,229	1,169,587	1,836.900	4,117,103	6,354,018	27,004,771
Sleepers	,,	64,663	..	10,231	73.874	78,965	278,658
Staves	,,	25,637	..	1,198,865	1,077,064	3,440,469	7,378,096
Rafts	,,	..	..	2	3	2	7
Building wood.	cubic metres	66,164	58,702	42,607	51,270	817,184	1,214,784
Cheese	kilogr.	516,015	578,863	383,280	554,615	1,016,362	10,330,170
Wine	,,	269,262	2,895,435	4,080,561	11,319,392	3,583,957	23,619,214
,,	barrels	..	1,081	1,328	28	..	4,107
Spirits of wine	kilogr.	737,425	3,264,851	2,019.707	288,223	2,300	6,312,506
,, ,,	barrels	..	..	..	2	..	2
Alcohol	kilogr.	..	..	..	1,135,805	1,107,283	2,243 088
Salt	,,	256,000	170,250	295,000	370,000	545,000	1,855,370
Tar	,,	20,446	27,740	45,475	21,830	23,135	3,843,656
Cattle	number	5,145	9,627	10,404	917	120	58,377
Horses	,,	..	..	36	9	123	168
Skins	kilogr.	171,674	97,962	25,056	49,413	7,800	812,960
,,	bales	34	..	6	13	9	11,216
Laths	number	..	..	..	..	..	5,183,655
Pigs	,,	..	..	1,304	..	142	1,446
Wool	kilogr.	114,997	768,857	63.734	26,897	7,688	3.683,908
,,	bales	..	..	..	..	..	12,895
Suet	kilogr.	..	..	..	..	..	761,989
Petroleum	,,	..	..	..	..	..	10,430,745
,,	barrels	..	..	..	..	..	3.987
Pipes	number	..	..	..	..	..	521,299
Tobacco	kilogr.	..	..	27,084	..	..	27,084
Bricks	number	..	..	52,000	..	..	52,000
Nuts	kilogr.	..	..	..	28,138	28,650	56,788
Butter	,,	..	..	..	1,482	2,921	4,403
Sundries	,,	..	..	2,878,837	6,591,685	5.505,535	14,976,057

Miscellaneous.

CONGRESS ON INLAND NAVIGATION.

The Fourth International Congress on Inland Navigation, will be held in Manchester, on July 28th and following days.

The objects of the Congress are :—To promote the improvement of inland navigation, and of estuaries; to direct attention to the economical value of navigable waterways; to examine, generally, technical questions relating to the construction and working of canals; to receive the report of the International Statistical Commission appointed at the last Congress; and to take further steps towards the collection of statistics bearing on inland navigation.

The three previous Congresses were held respectively in Brussels, Vienna, and Frankfort-on-Maine. They were attended by delegates appointed by the Governments of the countries represented. The Board of Trade appointed Mr. Courtenay Boyle, C.B., and Mr. E. Leader Williams, C.E., to represent England at the Congress held in Frankfort, in 1888.

Communications have been addressed to the Governments of Germany, France, Austria, Belgium, Italy, Spain, Holland, Norway and Sweden, Denmark, Switzerland, Russia, America, Portugal, and Greece, inviting them to appoint delegates to attend the forthcoming Congress.

It is intended to have an exhibition of plans, maps, and models relating to inland navigation. At the Frankfort Congress, a similar exhibition was held, the most valuable contributions coming from the German Government, who spent £4,000 on their preparation. It is hoped that these plans and models may be available for re-exhibition in Manchester.

The Congress will comprise two sections :—No. 1, engineering; No. 2, trading and economy.

The discussions at the Congress will be conducted in English and French, and the proceedings published in English, French, and German.

All communications relating to the Congress should be addressed to the Secretary, at Lombard-chambers, 46, Brown-street, Manchester.

THE FORESTS OF GERMANY.

According to a work recently published by one of the State foresters of Prussia, the entire forest area of Germany now amounts to 14,000,000 hectares (34,596,000 acres). Russia has 200,000,000 hectares (494,228,620 acres) of forests; Austria-Hungary, 19,000,000 hectares (46,952,000 acres); Sweden, 17,000,000 hectares (42,010,000 acres); France, 9,000,000 hectares (22,241,000 acres); Spain, 8,000,000 hectares (19,769,000 acres); Italy, 4,000,000 hectares (9,884,572 acres); and England, 2,471,000 acres. The United States Commercial Agent at Mayence says that the proportion of communal to State and Crown forests in the different States of Germany is as follows :—Prussia, 1,355,000 hectares of communal and 2,423,000 State forests; Bavaria, 388,000 and 941,000 respectively; Wurtemburg, 190,000 and 192,000; Hesse, 90,000 and 67,000; Baden, 259,000 and 93,000; and Alsace-Lorraine, 195,000 and 151,000 hectares. In Saxony and in the other States of the Empire, with the exception of Saxe Meiningen, about one-half of all the forests are State or communal property, considering the possessions of the Crown as a species of State property; and these are all subject to a well-regulated permanent administration and supervision under State control, while the older forests in many of the States are not under any public control. It is stated in the work referred to above that there are 9,100,000 hectares (22,487,400 acres) of coniferous, and 4,800,000 hectares (11,800,000 acres) of foliaceous trees in Germany. Of the coniferous trees it is stated that a greater part are on a soil adapted only to such growth, and on which nothing else can be cultivated. Of the coniferous trees, 3,000,000 hectares (7,413,000 acres) are of the fir kind, and 6,000,000 hectares (14,826,800 acres) pines. The greater part of the pines are in the mountains, preponderating in the Hartz mountains, the Riesengebirge, the Erzgebirge, in the Thuringian forests, in the Verm, in the Vosges mountains, in the Black Forest, in the so-called Bavarian Alps, in the Bavarian Forest, and in the Franconian, Jura, and Fichtel mountains. The pines are mostly on level tracts, and more than half of then are on soil unfit for the successful cultivation of useful timber. The 4,800,000 hectares of foliaceous trees are principally made up of beeches.

MEETINGS FOR THE ENSUING WEEK.

TUESDAY, MAY 27...Royal Institution, Albemarle-street, W., 3 p m. Mr. Andrew Lang, "The Natural History of Society." (Lecture I)

Medical and Chirurgical, 20, Hanover-square, W., 8½ p.m.

Horticultural, Temple - gardens, E.C., 1 p.m. Summer Exhibition.

WEDNESDAY, MAY 28...Patent Agents, 19, Southampton-buildings, W.C, 3 p.m. 1. Annual General Meeting. 2. Mr. H. Howgrave Graham, "The Progress and Work of the Institute of Patent Agents."

THURSDAY, MAY 29...Royal Institution, Albemarle-street, W., 3 p.m. Professor Dewar, "Flame and Explosives." (Lecture IV)

FRIDAY, MAY 30...United Service Inst., Whitehall-yard, S.W., 3 p.m. Lieut. W. C. Crutchley, "Signalling between the Royal Navy and the Mercantile Marine."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly meeting. 9 p.m. Mr. A. A. Common, "Astronomical Telescopes."

Browning, University College, W.C., 8 p.m. A. paper by Mr. J. B. Oldham.

SATURDAY, MAY 31..Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. The Rev. Baring-Gould, "The Ballad Music of the West of England." (Lecture I.)

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FRIDAY, MAY 30, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

The Society's *conversazione* will take place at the Natural History Museum, Cromwell-road, S.W. (by permission of the Trustees of the British Museum), on Friday, 27th June.

The reception by the Duke of Abercorn (Chairman), and the members of the Council of the Society, will commence at 9.0 p.m.

The following portions of the Museum will be open :—On the Ground Floor—the Central Hall, British Saloon, Bird Gallery, and a portion of the Gallery of Fossil Mammalia ; on the First Floor—the East and West Corridors, and the Lecture Room.

The bands of the Grenadier Guards and the Scots Guards will perform during the evening.

Each member is entitled to a card for himself (which will not be transferable), and a card for a lady. In addition to this, a limited number of tickets will be sold to members of the Society, or to persons introduced by a member, at the price of 5s. each if purchased before the 14th June. After that date the price will be 7s. ; on the 27th June, 10s.

These tickets can now be purchased. They will only be supplied to persons presenting members' vouchers (which can be obtained from the Secretary) or a letter of introduction from a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter a remittance must be enclosed. Each ticket will admit one person, either lady or gentleman.

Light refreshments (tea, coffee, ices, claret cup, &c.) will be supplied.

As the number of tickets which can be issued is limited, early application is desirable.

Proceedings of the Society.

FOREIGN & COLONIAL SECTION.

Thursday, May 15, 1890 ; C. M. Kennedy, C.B., Member of the Council, in the chair.

The Chairman said—Before I call upon Mr. Washington Eves to read the interesting paper, for the purpose of hearing and describing which we are now assembled, I have some preliminary communications to make to you. In the first place the Secretary of State for the Colonies desires to express his regret that he is unable to be with you. Lord Knutsford has a previous engagement which precludes his attendance, but he says that no person possesses so complete information as Mr. Eves on the subjects on which he is about to speak. Baron Henry de Worms, the Parliamentary Under-Secretary for the Colonies, of whose interest in Colonial matters you are aware, is detained at the House of Commons, which is now sitting. Sir Charles Tupper, the High Commissioner of Canada, is also prevented from being present by another engagement, but expresses his satisfaction that Canada will be represented at the forthcoming Exhibition. It is hardly necessary for me to introduce Mr. Eves. You are well acquainted with his valuable services at the great Colonial Exhibition —an Exhibition second in interest and importance to none that have been held in London. You have read Mr. Eves's recent work on the West Indies, which places vividly before us the present condition of these Colonies. He has lately received the well-merited honour of Companionship in the most distinguished Order which is the recognition of Colonial service, a sphere of public usefulness in which we trust he will long be willing to employ himself.

The paper read was—

JAMAICA AND ITS FORTHCOMING EXHIBITION.

By C. Washington Eves, C.M.G.

I was much gratified upon receiving the request to read a paper upon this subject before the Foreign and Colonial Section of the Society of Arts, and still more so when I was informed that the suggestion was made by Mr. Kennedy, who represents this Society upon the Jamaica Exhibition Committee in England, and who has taken such a warm and practical interest in the work necessary to secure, so far as such work can be done in this country, the success of that undertaking. As a member of the Society of Arts for some time past, I have watched with much pleasure the attention which has been paid to Colonial matters. The promotion of the arts and manufactures of Great Britain must have an important bearing upon the Colonies, where the increasing cultivation of native products and raw material requires to be better known in the great manufacturing centres of the world, and especially in the United Kingdom.

This is an age of exhibitions. It seems to be the desire of every country in the world to show what it has done, and can do, for the development of resources which tend to the increase of general wealth, and the advancement of civilisation. Such a collection of products from all parts as was seen at the Colonial and Indian Exhibition of 1886, must, of course, be of rare occurrence, but the success of that great display has had an influence for good in all parts of the Empire, especially in opening the eyes of colonists to the value of products hitherto neglected, and in stimulating inquiry into resources which had previously been allowed to run to waste. It is, therefore, not surprising that Jamaica should have its exhibition, and that the movement should be regarded with much interest and sympathy in the mother country.

Before entering into details, a few general remarks upon the island itself might be made. It is not necessary upon an occasion like this to discuss its history or its political constitution; suffice it to say that under the able administration of Sir Anthony Musgrave the contemporary progress of the colony made a real start, that under Sir Henry Norman an enlarged political constitution was wisely and successfully established, and the warm sympathies of that Governor with every means of improving the position of the black population bore much good fruit.

The present Governor, Sir Henry A. Blake, has applied himself with remarkable energy to carrying on this work of improvement, and to him the success of the exhibition, its plans, organisation, and results, will be very largely due. The mind of the native population is particularly susceptible of being taught by practical example, by the exhibition of objects attractive to the eye, by specimens of form and colour, and by actual proof of the real advantages of steady industry. Lasting moral and social results may also be fairly expected.

Jamaica is singularly varied in its climate and natural features. Its general botanical resources are of a wonderful extent and richness; its useful or economic plants have been thoroughly investigated, although as yet a small number have entered largely into commerce. These latter have, however, received much attention from Mr. D. Morris, the present Assistant Director of the Royal Gardens at Kew, when he was in charge of the public gardens and plantations of the island, and one of the important features of the exhibition will be the proof of the value in arts, manufactures, and food, of the economic plants of Jamaica. The island is 144 miles long, its greatest width is 49 miles, and its least width—going straight across from Kingston to Annotto Bay—is 21½ miles. It contains 4,193 square miles. It is diversified by mountains and their attendant streams, and the climate ranges from 75° to 80° on the coast and flat lands adjoining, to 60° and 65° on the high mountains, such as the Blue mountain range. The dryness of the atmosphere upon elevated portions, such as the Santa Cruz mountains, has attracted much attention for its health-giving qualities, and its influence upon consumption and bronchial affections generally.

This diversified elevation is naturally conducive to variety of cultivation. Sugar is grown (though to a much less extent than formerly) in those parts of the island specially adapted to its cultivation, whilst the Blue Mountain coffee is the finest in the world. Fruit, especially the banana, is grown extensively. Cinchona bark does not, at present, appear to be increasing as an article of export, chiefly owing to the low prices at present ruling. If a febrifuge could be produced on the spot cheaper than quinine, there would be a better prospect of success for this industry. In the cultivation of tea the labour difficulty may possibly be felt. The director of public gardens, Mr. Fawcett, reports:—"From the Blue Mountain ridge down almost to the sea coast on the north side the conditions are favourable for the growth of tea. The plant has become naturalised, springing spontaneously from self-sown seed;" and the manufactured leaf, when shown at exhibitions, has been much approved. Jamaica oranges, says Mr. Fawcett, "ought to be able to hold their own anywhere against those from Florida; they are finer fruit, and produced at much less expense. Land in Jamaica is abundant and cheap, and the soil is fertile." A great drawback is that the fruit is either shipped in an improper condition, or is not packed with care. An object lesson in packing oranges will be one of the most useful features of the Exhibition. While upon this point, I might refer to some remarks made by Mr. D. Morris, in the paper read by him before the Royal Colonial Institute in February, 1887. Fruit equal to a value of £8,000,000 sterling is yearly imported into the United Kingdom. The import into the United States must also be very large, nearly the whole of the fruit grown in Jamaica going to that country. Mr. Morris says, and I quite agree with him, that "when fruit is produced in large quantities, and it possesses a distinct value in foreign markets, it is a matter which concerns the Government, no less than the people generally, to take every step that is practicable and suitable to place that fruit in such a market in the best possible condition. Great care is taken generally in the preparation of crops of sugar, coffee, cacao, pimento, tobacco, ginger, and other produce; but the careful and scientific treatment of fruit, although capable of yielding returns proportionately quite as large as any of these, is practically overlooked, and consequently the loss entailed upon both growers and shippers is enormous." We may hope that the Exhibition will produce such examples as will remove this reproach so justly made by Mr. Morris. Indeed, his remarks have had already considerable effect.

A select committee of the Jamaica Legislative Council recently reported as follows upon this question :—" Your Committee believe that one chief danger to the fruit trade lies in the fact that the parties engaged in packing fruit are ignorant of the best methods in force in countries where the trade has reached far larger dimensions than is likely to result in Jamaica, at least for some years to come; and they are of opinion that great benefit would accrue if experienced fruit packers could be introduced from the Mediterranean, or the Western or Canary Islands. If the trade accepts this suggestion, and should ask the Government to assist in introducing this class of skilled labour, your Committee recommend that the Government should render all the aid it can in its introduction."

It cannot be too plainly stated that the future of the fruit trade of this island depends mainly on the proper selection and packing of all kinds of fruit exported; and the trade will not only be injured directly but the island must also suffer, if those who are engaged in the business do not combine to do all that can be done to prevent the shipment of fruit of poor quality, or defectively put up.

The total acreage in Jamaica under cultivation and care, in 1879 and 1888, was as follows :—

	1879. Acres.		18 8. Acres.
Canes	44,948	....	33,616
Coffee	22,853	....	20,075
Ginger	130	....	218
Arrowroot	33	....	10
Corn	649	....	822
Tobacco	341	....	167
Cacao	37	....	935
Vegetables	44	....	51
Ground provisions	58,444	....	79,382
Guinea grass	122,369	....	122,197
Common pasture	272,431	....	313,137
Common pasture and pimento	42,010	....	44,539
Pimento	1,155	....	1,455
Total number of acres under cultivation and care	565,448	....	616,594

Note.—Fruits are not included in the above statement, as they grow indifferently among other products.

It cannot be held that the above figures show any sensible advance in ten years. The most satisfactory items are the ground provisions, grown by the peasantry occupying small holdings; and the cacao cultivation. There are a number of small settlers in Jamaica, growing patches of cane, and possessing sugar mills made of the hard woods of the country. The appliances are no doubt very crude, but if they could be improved, and the extraction made more economically, such an industry might increase.

Of the actual resources of the island available for export, the Table of Exports for the years 1888 and 1889 respectively may be taken :—

	1888.	Value.			1889.	Value.		
		£	s.	d.		£	s.	d.
Annatto	524,429 lbs.	3,583	11	9	.. 455,874 lbs.	3,798	19	0
Arrowroot	27 cwts. 2 qrs. 21 lbs. ..	38	3	6	.. 7 cwts. 1 qr. 14 lbs.	11	6	8
Beeswax	1,033 cwts. 1 qr. 21 lbs. ..	4,822	15	0	.. 1,018 cwts. 0 qr. 22 lbs. ..	4,571	11	8
Cattle, neat	79	790	0	0	.. 26	260	0	0
Cocoa	4,750 cwts. 0 qr. 6 lbs.	10,640	2	5	.. 5,248 cwts. 3 qrs. 19 lbs. ..	10,581	16	5

	1888.	Value.			1889.	Value.		
		£	s.	d.		£	s.	d.
Cocoanuts	5,909,301 (number)	20,682	10	10	4,831,615	15,219	11	9
Coffee	98,965 cwts. 2qrs. 8lbs.	321,440	2	3	84,606 cwts. 0 qr. 8 lbs.	291,383	6	2
Cinchona bark	4,015 (number)	151	7	6	3,321 (number)	66	0	0
Fruit, bananas	3,093,393 bunches	270,671	17	9	2,881,313 bunches	252,114	17	9
„ limes	634 barrels	317	0	0	701 barrels	350	10	0
„ mangoes	299,584 (number)	258	9	0	170,988 (number)	100	19	6
„ oranges	47,910,177 (number)	64,678	14	8	35,394,271 (number)	51,321	13	10
„ pineapples	9,812 dozens	1,471	16	0	8,292 6-12 dozens	1,036	11	3
„ shaddocks	10 barrels	5	0	0	33 barrels	16	10	0
Ginger	10,222 cwts. 0 qr. 13lbs	19,462	18	2	8,952 cwts. 1qr. 1lb.	18,615	8	9
Hides	277,828 lbs.	5,788	2	6	260,641 lbs.	6,516	0	6
Honey	1,680 cwts. 1qr.	1,344	4	0	1,248 cwts. 1qr. 2lbs.	1,248	8	9
Horses and Mules	100 (number)	2,377	0	0	67 (number)	3,426	0	0
Lancewood spars	7,921 (number)	2,383	15	6	8,062 (number)	2,821	14	0
Limejuice	85,963 gallons	2,865	8	8	77,745 gallons	3,239	7	6
Pimento	66,559 cwts. 2qrs. 2lbs.	44,727	19	9	46,179 cwts. 3qrs. 21lbs.	47,842	8	4
Rum	1,868,490 gallons	202,419	15	0	1,374,931 gallons	137,493	2	0
Sheep's wool	19,418 lbs.	323	12	8	23,081 lbs.	384	13	8
Sticks (walking)	16,842 loose, 628 bundles	434	12	0	171,144 loose, 1,303 bundles	2,576	11	1
Succades	73 cwts. 0qrs. 22lbs.	469	14	0	48 cwt. 3qrs. 13lbs.	197	3	2
Sugar	490,480 cwts. 0 qr. 25 lbs.	288,402	7	9	323,238 cwts. 1qr. 1lb.	244,368	2	5
Tamarinds	4,939 lbs.	90	9	0	1,775 lbs. 32 kegs	45	15	0
Tobacco, cigars	7,008 lbs.	3,504	0	0	4,479½ lbs.	2,799	13	9
„ (unmanufactured)					1,593 lbs.	79	13	0
Tortoise shell	2,008 lbs.	578	11	0	3,673 lbs.	1,469	4	0
Turtle	2,688 (number)	4,244	10	0	2,742 lbs.	5,007	14	0
„ (prepared and dried)	8,587 lbs.	1,132	6	10	12,069 lbs.	1,529	17	0
Wood, bitter	218 tons 10 cwts	437	0	0	649 tons, 19 cwts	1,299	18	0
„ ebony	57 tons 5 cwts.	143	2	6	383 tons 2 cwts.	956	15	0
„ fustic	2,463 tons 8 cwts.	7,390	4	0	793 tons 8 cwts	2,142	3	7
„ lignum vitæ	20 tons 13 cwts.	61	19	0	446 tons 19cwts	1.251	9	2
„ logwood	100,901 tons 6 cwts.	353,154	11	0	115,454 tons	375,225	10	0
Yams	28,194 cwts. 1qr.	11,277	14	0	6,149 cwts. 0 qr. 16 lbs	3,074	11	6

The new struggling industries in the above list will be noticed. Tobacco makes no way at present. The difference in the export of yams between the two years suggests an unfavourable season for roots and ground provisions. Upon the whole, the above table presents a state of things which is certainly capable of great improvement. The valuable and historic industry of sugar, for instance—an expensive product requiring large capital for expenditure, principally in wages enjoyed by the industrial classes—should not be allowed to die out while Englishmen eat every year nearly a million tons of beet root sugar, produced by foreign labour, and aided by foreign State bounties. A careful consideration of the above figures will show that there is much to be done, not only in maintaining existing industries but in planting new ones, a number of which have been suggested, and will be referred to later on; and it is for the purpose of calling attention to the undeveloped agricultural wealth of the island that an exposition of its capabilities is so much desired.

As the exhibition is primarily a display of Jamaica products, it was opportune on the part of the Governor to issue a "Message to the People," recommending local effort in every part of the island. His Excellency mentions that prizes will be offered for samples of the following, among many other things, grown or made by the people:—Sugar-canes, cacao, kola, bananas, oranges, ground provision, cocoanuts, Sisal hemp, Manilla hemp, tobacco, cigars, cinchona, coffee, peppers, ginger, pimento, rum, logwood, fustic, annatto, castor oil, cocoanut-oil, cattle and horses, sheep, pigs, poultry, birds, fishes, turtle, bees, carpentry, cabinet-making, basket-work, nets, mats, goldsmiths' and silver work, models of cottage homes, boats, fancy work, &c. Greater researches for minerals are recommended. Gold, silver, and copper have been discovered in the Charing Cross mine, and ten tons of ore have been recently shipped to London. Special arrangements are also suggested for collecting large samples of the various rubber substances to be obtained from a number of trees. From the mineral, vegetable, and animal kingdom, a great variety of raw material could be obtained, some that might locally be manufactured or prepared for consumption, and others useful to the manufacturer abroad. In the different parishes are found limestones, sandstones, flagstones, marbles, road materials, sands, ochres, clays, ornamental and precious stones, gypsum, copper ores, lead, iron, zinc, cobalt, manganese, antimony, gold, and silver. Few countries are better supplied with building-stone, which varies in degree from the finest marbles to coarse but enduring sandstones. Fine marbles of different patterns and colours are found in many parts. There is a great extent of granite rocks.

The above-mentioned industries, or certainly many of them, are as yet small and undeveloped. They require time, patience, industry, skill, and intelligence, and a great help might be given by immigrants and settlers from Europe. At all events it was to obtain a good display of these natural productions, to bring them before the skilled observation of the specialist from Europe and America, that the Exhibition has been planned.

The general classification of exhibits, as at present proposed is as follows :—

GROUP I.

RAW MATERIALS.

Class 1.—*Raw Materials in the Mineral Kingdom.*

(*a*.) Minerals.
(*b*.) Ores.
(*c*.) Phosphates and other natural manures.
(*d*.) Rocks and their contained fossils.
(*e*.) Mineral springs of Jamaica, their analysis and value.

Class 2.—*Raw Materials in the Vegetable Kingdom.*

(*a*.) Foods—Sugar-canes, cereals, roots, cacao, kola.
(*b*.) Fruits and vegetables—Bananas, oranges, &c.
(*c*.) Fibres—Sisal hemp, Manilla hemp, cocoa-nut, cotton, ramie.
(*d*.) Timbers.
(*e*.) Drugs—Tobaccos, coca, cinchona, &c.
(*f*.) Condiments and stimulants—Coffee, peppers, ginger, pimento, rum.
(*g*.) Dyes—Logwood, fustic, annatto.
(*h*.) Oils—Castor oil, cocoa-nut oil, essential oils.
(*i*.) Ornamental plants.

Class 3.—*Raw Materials in the Animal Kingdom.*

(*a*.) Cattle and horses, sheep, pigs, &c.
(*b*.) Poultry, birds, fishes, turtle, &c.
(*c*.) Bees and silkworms at work.
(*d*.) Wool, horn, turtle shell, corals, &c.

GROUP II.

IMPLEMENTS FOR OBTAINING RAW MATERIALS.

Class 4.—*Implements used in*—

Mining.
Geology.
Extracting Ores.

Class 5.—*Agricultural and Horticultural Implements.*

Class 6.—*Fishing Implements. Guns and Hunting Equipments.*

GROUP III.

MACHINES AND PROCESSES USED IN PREPARING AND MAKING UP THE RAW MATERIALS INTO FINISHED PRODUCTS.

Class 7.—*In the Mineral Kingdom.*

(*a*.) Potter's wheel, &c.
(*b*.) Glass-blowing
(*c*.) Making china, firing, &c.
(*d*.) Cutting and mounting precious stones.
(*e*.) Metal work, blacksmiths' work, &.

Class 8.—*In the Vegetable Kingdom.*

(*a*.) Sugar machinery, curing cacao, making arrowroot, tapioca, starch, corn shellers, and driers.
(*b*.) Fruit evaporators, packing oranges, &c.
(*c*.) Fibre extracting, rope making, mat making, hat and basket making, weaving cotton, paper making.
(*d*.) Carpentry, cabinet making.
(*e*.) Making cigars and cigarettes.
(*f*.) Coffee machinery, rum distilling.
(*h*.) Apparatus for expression and distillation of oils.

Class 9.—*In the Animal Kingdom.*

(*a*.) Curing meat and fish.
(*b*.) Model dairy, making butter.
(*c*.) Preparing silk and wool, and weaving them.
(*d*.) Cutting and preparing tortoise shell and bones.

GROUP IV.

MANUFACTURED GOODS.

Class 10.—*In the Mineral Kingdom.*

(*a*.) Pottery, glass, china.
(*b*.) Jewellery.
(*c*.) Sewing machines, needles, and other apparatus for making up clothing.
(*d*.) Apparatus for heating and lighting, metal house-accessories.
(*e*.) Steam-engines, prime motors.
(*f*.) Goldsmiths' and silversmiths' work, bronzes, clocks and watches.

Class 11.—*In the Vegetable Kingdom.*

(*a.*) Sugar, chocolate, starches, bread, and pastry.
(*b.*) Preserves, dried and crystallised fruit.
(*c.*) Thread, cordage, mats, brushes, paper, textile fabrics.
(*d.*) Furniture, wood-work, farm buildings, model dwellings.
(*e.*) Drugs.
(*f.*) Coffee, rum, pepper.
(*g.*) Dye stuffs.
(*h.*) Oils.

Class 12.—*In the Animal Kingdom.*

(*a.*) Cured meat and fish.
(*b.*) Dairy produce.
(*c.*) Woollen and silk goods.
(*d.*) Leather, horn, bone goods, &c.

Class 13.—*Goods made up of Materials from more than one of the Groups* 1, 2, 3.

GROUP V.

Education.

Class 14.—*Kinder-garten Appliances.*
Class 15.—*Industrial School Appliances.*
Class 16.—*Organisation, Methods, and Appliances for Ordinary Education in Schools.*

GROUP VI.

Fine Arts, Literature, and Science.

Class 17.—*Fine Arts.*

(*a.*) Architecture.
(*b.*) Painting, drawing, photography.
(*c.*) Sculpture.
(*d.*) Music.

Class 18.—*Literature and Accessories.*

(*a.*) Books, &c., on Jamaica and West Indies.
(*b.*) „ „ British Isles.
(*c.*) „ „ British Colonies (exclusive of *a*)
(*d.*) „ „ America.
(*e.*) „ General.
(*f.*) Bookbinding.
(*g.*) Printing.

Class 19.—*Science.*

(*a.*) Maps and charts of the West Indies.
(*b.*) Engineering, sanitation, gas, electricity, astronomy.
(*c.*) Anthropology.

But the point I wish specially to bring before your notice is, how far we in this country can supplement the local resources, and lead to their fuller utilisation. The work of the Exhibition Committee in England is divided into two parts—1st, the obtaining of machines or models showing the latest improvements in the manufacture of sugar and rum; the extraction of cocoa-nut and other oils by compression; the preparation of cocoa-nut coir or fibre; the extraction of fibres from the leaves and stems of plants; machines and appliances for curing and preparing coffee, cacao, pimento, annatto, spices, ginger, meals, starches, dyes, essential oils, perfumes, and medicinal substances; fruit-drying machines, small windmills, turbines, and other time and labour saving machines. This is the first and perhaps the most important point to which we have directed our attention, namely, the application of English machines and appliances to the native raw products. The second point is that we have endeavoured to call the attention of merchants and manufacturers in this country to the market offered to their goods by the 620,000 people in Jamaica; large quantities of perishable goods, provisions, lumber, &c., are naturally obtained from the nearest markets, viz., the United States and Canada; but hardware, cutlery, linen, calico, and woollen goods are generally supplied from the United Kingdom. There never, perhaps, was a time more opportune than the present to remind English manufacturers of the serious extent to which German and other foreign manufacturers are competing with them, particularly in the West Indies and South America. Jamaica occupies, too, a central position, which has never been fully utilised, as an entrepot of trade, and this position would of course have become of first-rate importance had the Panama Canal been formed.

Now, in illustration of the first of the above points, viz., appliances for raw products, I would mention what has been done in regard to perfumes and fibres. Plants yielding oils and perfumes are abundant in Jamaica, and they offer a wide field for the operations of the chemist and the cultivator of flowers for their perfumes. Many of the plants are very abundant, and obtainable in large quantities; others, like the tuberose and jasmine, require to be cultivated. But the formation of flower farms and the extraction of perfumes is still in want of encouragement. Some of the extracts and essential oils, however, which are well known, are the wild cinnamon, vanilla, jasmine, lily, red muskwood, rosewood, orange, verbena, lemon, lime, pimento, blue gum, lemon grass, mountain thyme, ben-nut, cocoanut, walnut, &c. The drawback has hitherto been the want of the most effective and economical machines for extraction. Upon the Continent of Europe there is a very large manufacture of perfumes, and through the good offices of Mr. Kennedy, a valuable report has been addressed by Mr. J. C. Harris, the British Consul at Nice, to Lord Salisbury, giving details of the process used for producing scent, and especially describing, with a plan, the machine employed. The information thus given will be extremely useful in Jamaica.

Jamaica is rich in fibres, and a serious attempt is to be made to utilise them for several purposes. Bamboo and megass (or the sugar-cane after crushing) might become important for paper making. In the event of the Esparto grass failing, as was at one time feared, a substitute becomes very important. I have some excellent specimens of paper stock and writing paper, made some years ago by Mr. Routledge, from bamboo and megass. There are many other uses for the fibres found in Jamaica. What is wanted is a good and inexpensive machine for their extraction. The Institute of Jamaica has offered a prize of £50 for the best set of machines which may be shown at the Exhibition. I have communicated with the principal English and foreign manufacturers upon the basis of information forwarded by Mr. Morris, of Kew. It might be interesting to quote some extracts :—

"The set of machinery might include a banana machine, as well as others. The banana machine should be portable and simple, adapted for the expression of water from the stem of the banana, to be constructed especially for the use of small plantations, and at a cost so as to be placed within reach of small cultivators.

"The following native and other fibre plants are already found in Jamaica, and machines are desired to clean the leaves or stems of any of them.

I. Aloe Family.—1. American aloe (*Agave americana*). 2. Keratto (*Agave Morrisii*). 3. Sisal hemp or henequen (*Agave rigida*). 4. Fœtid aloe or Mauritius hemp (*Furcræa gigantea*). 5. Silk grass (*Furcræa cubensis*). 6. Dagger plant (*Yucca aloifolia*). 7. Bowstring hemp (*Sanseviera zeylanica*). 8. Bowstring hemp (*Sanseviera guineensis*).

II. Ananas or Pineapple Family.—1. Pineapple (*Ananassa sativa*). 2. Pinguin (*Bromelia pinguin*). 3. Silk grass (*Karatas Plumieri*).

III. Banana and Plantain Family.—1. Banana (*Musa sapientum*). 2. Plantain (*Musa sapientum*). 3. Manila plantain (*Musa textilis*). 4. Abyssinian plantain (*Musa ensete*).

IV. Nettle Family.—Ramie or rhea (*Boehmeria nivea*).

"As regards the fibre of the plantain and banana, it is estimated that about two million stems of these plants, after bearing fruit, are cut down every year in Jamaica. In the absence of a suitable machine to prepare the fibre, these stems are allowed to rot on the ground, or are converted into manure. A full-grown plantain or banana stem weighs about one hundredweight, and contains only about two pounds of fibre. The bulk of the stem is made up of watery juices and soft pulp. A simple and effective machine of the nature of a wringing or mangling machine is required, through which portions of the banana or plantain might be passed to free them from water. The machine must be portable, and the rollers should be made of hard wood. Iron would soon rust, and also be too heavy. When the stems have been passed through the machine, they could then be easily carried to a more elaborate fibre machine, or taken to the nearest stream and washed and beaten.

"It is well known that banana fibre is not of high value, and probably would not be worth more than one penny or penny half-penny per pound. On the other hand, its production, under present circumstances in Jamaica, would entail very little expenditure, and, with a suitable machine, would bring in a considerable revenue to the cultivators. Even at one penny per pound, Jamaica could produce banana fibre worth about £20,000 per annum."

We also want information as to the latest processes of sugar-making—that is the means of extracting the greatest quantity of juice from the cane, and the greatest quantity of sugar of good quality from the juice. We should like to obtain, for instance, a model of a diffusion plant, now so largely used in Europe in the beet factories. It is possible that the fibres of the cane may prevent the rapid and easy slicing by knives, which is found adapted to the beet-root, and that the process may not be found a good substitute for the old-fashioned system. I believe that enterprising planters, both in Demerara and St. Lucia, are making practical experiments, and we hope to be able to obtain for the information of sugar makers in Jamaica a model of the apparatus employed. Rum distillation, too, is important for Jamaica. Rum is a natural product of the sugar-cane, and is an article for which Jamaica has long been famous, the flavour and quality depending not so much upon manufacture as upon soil. The Chancellor of the Exchequer recently asked, "Who drinks rum?" It is evident that a considerable quantity is drunk, and some is no doubt employed in the manufacture of European brandies and whiskies. So long as there is a demand for rum, Jamaica is justified in producing it, and no other country has such natural advantage for its production. A knowledge of the latest improvements in distillation might supersede the somewhat crude and rule-of-thumb method too frequently adopted.

It would be also interesting to obtain models or specimens of machines for preparing the coffee berry for consumption, and others showing the different forms into which cocoa and chocolate are made such attractive articles of food. The preparation of turtle for food, castor-oil for medicine, and the different gum and rubber manufactures, would likewise be desirable for the exhibition.

We are also desirous of drawing attention, by an aquarium, to the fishes of Jamaica and the small islands which constitute her dependencies. The salt, sponge, and pearl industries of the Cays will of course be illustrated. Mr. Sinclair, the energetic superintendent of the Government printing establishment, is arranging exhibits of English and foreign printing and book-binding. We have asked the Postmaster-General to lend us some of the apparatus and appliances which he is showing in the City of London in honour of the jubilee of the penny post. Improvements in postal arrangements should naturally follow the reduction of postage rates, which will be such a decided boon to the Colonies. We applied to the South Kensington Museum to lend us some pictures and other works of art, but the Treasury regulations do not admit of such objects being lent to places outside the United Kingdom. Works of art, indeed, are specially desired, and it is possible some members of the Society of Arts might assist us in this respect. We lose nothing by asking, and we hope the Queen and the Prince of Wales will show a gracious interest in our undertaking by lending us a few objects from their collections.

In the Governor's Message to the People, the rearing of sheep and cattle is referred to. In a letter from Mr. L. F. Mackinnon, the secretary of the Exhibition in Jamaica, he discusses this question as follows :—

> "Proper accommodation will be provided for any sheep that are sent, but, of course, the exhibitors will have to pay the cost of their keep. Sheep are bred here in considerable numbers, and are remarkably free from disease, but they degenerate very quickly in size and yield of wool, and have to be kept up by importation of fresh blood from Europe and America. The breed most in favour are Southdowns, Shropshires, and Cotswolds, but at our agricultural show, a couple of years ago, two Lincoln rams, which are the only ones I have ever seen in the island, took the first prize. I think Lincolns would do well here, as size is what we want, and breeders do not go in for pure-bred flocks, but cross their sheep with any pure-bred ram they can get, as there is a theory here that cross-bred sheep are hardier, and less liable to disease than pure-bred ones. I should not advise your correspondent to send out high-priced rams. They must be pure-bred, but such as he can sell here from £15 to £25. With regard to Hereford cattle, there is no doubt that the breed is increasing very much in favour in the colony, but I should not recommend any one to send an exhibit of pure-bred cattle of any kind that are over 15 months old, as above that age the death-rate in imported cattle is very high, while below that age they get acclimatised readily. While on the subject of stock, I may say that pigs and poultry thrive as well here as in England, and so do thoroughbred horses and donkeys."

So much depends upon efficient means of communication, especially the bringing of fruit and produce of all kinds rapidly to the ports for shipment, that the railway extension recently undertaken by an American body of capitalists should be mentioned. Since 1877, the railway from Kingston to Old Harbour, having been taken over by the Government, was gradually extended in several directions into the interior of the island. The extensions now being carried out will open up new and fertile districts in the interior, and connect Kingston with the northern ports of Montego Bay and Port Antonio. The work, when finished, will represent a capital of one and-a-half millions sterling. The length of roads available for wheel traffic will gradually be increased by from 1,000 to 1,300 miles. Nothing more important could be devised for the development of the colony than road-making, and Sir Henry A. Blake, in pushing on this work, is adopting a thoroughly sound policy.

An agent has been appointed to receive the goods, and be responsible for their proper care and return. There will be no charge for space occupied by goods not intended for sale. The goods will be taken, at half the usual rates of freight, by the Royal Mail Steam Packet Company, and favourable terms will also be granted by the other steamship companies trading with the West Indies. Applications tor space should be sent in by the 1st of July, so as to allow of accommodation being provided for the reception of goods during the last two months of this year.

I may add a remark upon the financial aspect of the exhibition. Its success is amply assured by a guarantee fund of £30,000. The exhibition is being built in a beautiful and commanding position north of the Kingston Racecourse, with a background of the Jamaica hills. The length of the building will be 511 feet. The interior will be a nave with side aisles and galleries, the latter being used as promenades. In the centre of the building there will be a dome of a terminal height of 114 feet. The length of transept will be 174 feet; the minarets or smaller towers, rising to 73 feet, will give lightness and variety to the design. The breadth across nave and aisles will be 81 feet, and the height of nave will be 59 feet. The West Indian Court at the Colonial and Indian Exhibition will, perhaps, give a fair idea of the interior arrangements of the building in Jamaica.

The ornamental garden now being laid out by the Director of Public Gardens, will be 12 acres in size, and the racecourse grounds in the front of the building cover 45 acres. Practical attention is now being paid to the question of hotel accommodation for the numerous visitors expected from Europe and America.

The Prince of Wales has been pleased to take an interest in the undertaking and to become its patron, and Prince George of Wales, who will be in command of his ship in West Indian waters at the time, will open the Exhibition. The old and loyal colony of Jamaica will, I feel sure, give the Prince a hearty welcome.

DISCUSSION.

Sir Henry Barkly, G.C.M.G., said he had listened with very great pleasure to the interesting description which had been given by Mr. Washington Eves of the proposed Exhibition in the island of Jamaica, and he thought he had shown very good grounds for believing that it would be productive of very beneficial results to the inhabitants of that island, besides tending to promote the interests of trade. Having spent many very happy days in Jamaica in former years, he could never cease to take a warm interest in the welfare and prosperity of all classes of the population, and when he was asked to become a member of the Exhibition Committee he agreed to do so with very great pleasure, although he was afraid he could not be of much use to such an undertaking in the position which he at present held. However, he had attended the meeting, and had listened with very great satisfaction to the account of the progress which was being made in preparing for the Exhibition, and he trusted it would receive such support on this side as was necessary to make it a complete success upon the other. He would not follow Mr. Eves through the account he had given of the various branches of industry which it was designed to promote, because it was unnecessary so to do. He was obliged to the reader of the paper for the brief summary he had given of the projects in view, and he was glad to find that although progress had not been exceedingly rapid, yet there had been some progress during the last ten years in the development, at any rate, of the minor products. Sugar had not been making any great advance, and while the price continued so low he was afraid it would not advance by "leaps and bounds," though he hoped that the cultivation would be maintained on the estates which could produce it at a reasonable figure. From the valuable handbook on Jamaica, by Mr. Morris, of Kew, it was seen that a great deal was being done to promote the minor industries.

Mr. Morris said the arrangements which had been made by the London Committee had been of so thorough and satisfactory a character that, as far as one could judge at present, there was every indication that makers of machinery and others would send out appliances to the Exhibition, and there was but little doubt that immense good would result to the island from the Exhibition. He had been connected with Jamaica for several years, and had taken a deep interest in its industries. The great difficulty they had always met in regard to new industries, was the want of appliances to prepare the raw material, so as to export it in such a state as that it could compete with that of other countries. It had long been felt that Jamaica had turned the corner, and although the statistics to which they had just listened were not of a very encouraging character as regarded the actual exports, yet there was, he was convinced, more life and energy now being displayed in regard to the various industries than formerly, and he thought Sir Henry Blake and the Government of Jamaica were well advised in doing what they could to make the Exhibition a great success. No doubt many friends on this side would be willing to do their part, and the accounts received by every mail showed that the people upon the other side were doing their very best. Mr. Eves had stated that the cost of producing cinchona was too great for it to be successfully cultivated in Jamaica, but he thought that was not quite the case. After the cultivation had been carried on for some time, the price fell so low that it was really not worth exporting, and no doubt it would be better for the people to keep their trees for the present, and let the bark become more matured, so that when the price rose they would get a better return. The cinchona trees were more healthy in Jamaica than in many parts of the East Indies, so that he had little doubt about the ultimate success of the industry. As to tea, he thought that in face of the enormous shipments from Ceylon and India, that it would not be wise for the people of Jamaica to take up this matter. The fruit industry was one which had grown very considerably within the last fifteen years, for whereas in 1876 the total value of the fruit exported was only about £10,000, it was now between £300,000 and £400,000. That trade had done a great deal of good to the island generally, though there was no doubt better picking and preparation of the fruit would still further increase its value. The oranges grown in the island were very fine. With regard to fibre industries, he had urged the people to take up this branch, and as the price rose 50 per cent. during the last four years, they might have reaped the full value of the increase. However, it was not yet too late to take up the matter. The Jamaica Institute had offered a prize—£50 for a set of machines to produce fibre in different stages, and he had great hopes of such a machine being brought out. They also wanted a machine for preparing Liberian coffee. Latterly the price of this coffee had increased to such an extent that in Java, it fetched a price equal to that of the best estates coffee, and it could be grown upon the old sugar plantations. With regard to the rum industry, attempts were now being made for the first time to carefully examine the yeast, and trace the real cause of the different qualities of rum produced. There were numerous industries in Jamaica which might be taken up, but the people were so comfortable, and so satisfied with their beautiful climate, that it was very difficult to stir them, and get them to take sufficient trouble to develop fully the resources of the country. He had no doubt that the Exhibition would be a very great success, and that it would be a benefit not merely to Jamaica, but to the whole group of our possessions in the West Indies.

Rev. D. J. EAST, who had resided for thirty-eight years in Jamaica, and worked in the education of the labouring classes, said his interests had been for the most part identified with the labouring classes, but he had a common interest in whatever concerned the prosperity of the island. He felt personally indebted to Mr. Eves for the enterprising spirit he had displayed, for the stimulus he had endeavoured to give, not only to those interests with which he was personally more identified, but with the whole interests of the island. The great want of the island with regard to minor products had already been dealt with by Mr. Morris. What was wanted was a better class of machinery, both with reference to fruit and fibre. The people needed instruction as to the gathering of the fruit. He had seen oranges pulled from the trees, thrown into carts, and brought into Kingston in a condition which gave very little promise of their realising a return. He had also seen them hand picked and properly packed, first in paper, and then in suitable barrels for their conveyance, and the difference in the result had been perfectly amazing—the one method as contrasted with the other. The forthcoming Exhibition would, in his opinion, tend to instruct the people, and show them better modes of fulfilling the important interests which they might serve, not only for themselves, but for the country at large. Another great want in connection with the fruit industry was better roads in order to bring the produce to the wharves for shipment, and he was glad to know that Sir Henry Blake was giving special attention to this subject. Only a short time ago he received a letter from his Excellency in which he stated that he had a scheme for the improvement of the parish roads, so that instead of the old plan with which Mr. Morris was so well acquainted, of carrying fruit for long distances on mules, or on the heads of the people, it would be able to be carried to the wharves by roads suitably constructed for the purpose. This improved means of getting to the market would largely contribute to the value of the industry to the island. He thought Jamaica might supply the world with fibres. Some of the most valuable fibrous roots would grow on land which was hardly suitable for any other production; but the great want with reference to fibre was suitable machinery. They had not yet had a machine of so simple and effective construction as to be of much use, especially to the peasantry of the country. He had great expectations upon this matter from the Exhibition. The depressing influences from which Jamaica still suffered did not depress his mind with regard to its future, for considering the fertility of the soil, and the growing intelligence of the labouring people, consequent upon the fact of there being now nearly 800 elementary schools under Government inspection, there was every hope for the island becoming a most prosperous one. The reader of the paper had not given too glowing a description of the prospects consequent upon the usefulness of the Exhibition, to which all were looking forward.

Mr. SHORTRIDGE said, as an old inhabitant of Jamaica, having resided there 45 years, he could confirm every word that had been said by Mr. Eves, by Mr. Morris, and the Rev. Mr. East. These gentlemen had dealt with things as they really were, so that there was nothing left for him to add.

Mr. H. STERN said, as a native and resident of Jamaica, he had been very much interested in the paper. He knew the good that had been done to the colony by Mr. Eves, and it was such friends that Jamaica wanted—men who, besides sentiment, were willing to give their time and energy to forward its interests. Jamaica had for a long time suffered by people running it down without any real knowledge of the advantages to be derived from it. The idea of the Exhibition had completed what Mr. Eves had commenced, and, if nothing else, it would be an immense advertisement for Jamaica. This place was not the pest hole which sometimes it was represented to be; it had the advantages of soil and climate, and prospects for capital and energy. Reference had been made by Mr. Morris to the advantages which might have been reaped by cultivating fibre plants, but it was no use doing so unless they had a machine to extract the fibres. Some years ago the Government offered a prize of £50 for any machine which would extract the fibre from the Sisal hemp, and a machine was invented by Mr. Kennedy, but it was found that that would not extract the fibre with sufficient economy to make it marketable. He was very glad to see that another prize had been offered, and he hoped that some good would result therefrom. As the merchants in Jamaica were endeavouring to get from their commercial agents exhibits from different parts of the world, and the Governor was doing his best, there was no doubt the Exhibition would be an advantage to the colony, and if so, it must be of advantage to the empire.

Mr. MORRIS remarked that fibre machines had been at work for eleven years in Yucatan, and six years in Mauritius. There was no great difficulty about cleaning Sisal hemp, or the pineapple family; the great difficulty had been with regard to the banana and ramie. He had examined some machines at Paris for dealing with China grass, and it was hoped that M. Favier would send one of his machines to the Exhibition. These machines would prepare one ton per day of the ribbons. The cost of such machines was about £80, while the machines in use at Mauritius cost £25. Full particulars of these machines are given in the *Kew Bulletin* for November, 1889, and May of this year.

Mr. O'HALLORAN asked what success had attended the efforts of Mr. Morris to cultivate Manilla hemp, which was always marketable, and in very great demand.

Mr. MORRIS said the Manilla hemp, which was yielded by a kind of banana, was introduced into Ceylon and Jamaica a good many years ago, but, unfortunately, they had not been able to get it to flourish; in fact, they had the utmost difficulty even in keeping the plants alive at Kew. He did not believe that the Manilla hemp could be a success in the West Indies. It had been under cultivation in Trinidad, Demerara, Dominica, and at St. Vincent, but they had found that at no spot outside the Philippine Islands would the plant flourish. It would be possible to send the Manilla hemp to any part of the West India Islands, where the conditions were likely to be favourable, but up to the present the results had been most disappointing.

Mr. SCOTT regretted that more attention had not been devoted in the discussion to the sugar and cocoa industries. He thought, also, great advantages might be derived from the Exhibition in connection with the United States and Canada.

Mr. MORRIS replied that the cultivation of cocoa in Jamaica was well understood, as was also the preparation of the bean. It was understood they had really been talking that evening of industries which had hitherto lacked success on account of the absence of machinery, or from want of special knowledge. They could not expect to cover the whole of the ground at that meeting, though he was very glad that Mr. Scott had mentioned the subject. They were now dealing with the special difficulties which had hitherto arisen in Jamaica. He believed as land was opened up, and the facilities for transport improved, the cultivation of various industries, both new and old, would be undertaken in the West Indies.

Mr. SCOTT thought some inducement should be held out to manufacturers in this country to go out to Jamaica for the purpose of exhibiting their ingenuity and manufactures. Unless manufacturers could see their way to getting some return, it was hardly to be expected that they would go to the trouble and expense of exhibiting.

Sir FREDERICK YOUNG, K.C.M.G., said, as one who had taken an extreme interest in this important subject brought under their notice by Mr. Eves, he hoped that the paper and discussion would be very widely circulated, knowing that great good would result therefrom. He had the honour of being on the committee of the Jamaica Exhibition, and after the remarks of Sir Henry Barkly, he felt very much tempted to go and spend a few happy days in the island when the Exhibition was opened. He could only say that he was very much delighted with the paper, and with listening to the important points which had been raised in the discussion.

The CHAIRMAN said:—The Society of Arts has always taken a warm interest in exhibitions, and has been connected in some degree with those held in London and abroad between 1851 and 1889. I have been duly sensible of the honour of being selected by my colleagues on the Council to represent this Society in connection with the Jamaica Exhibition, and must express my best acknowledgments for the kind terms in which Mr. Eves has spoken of my action. It has been an additional pleasure to me on personal grounds. The beautiful scenery of Montego Bay is one of my first recollections. I do not know how it may be now, but 50 years ago there were great differences between the coast aspect of Jamaica, and of San Domingo and Cuba. These larger islands are equally beautiful in scenery, but in those days Jamaica alone seemed well cultivated, and to show along the coast line the residence of a population in favourable conditions of life. The West Indies possess to us in a peculiar sense national interest. The seas of these islands were the nursery of English seamen in the days of those stupendous conflicts with Spain and France, the result of which was to confer on England the empire of the ocean; these islands are thus very intimately associated with the greatness and expansion of England; they are replete with remembrances of her chief admirals; they were the scene of the achievements of Drake, Rodney, and Nelson. It will be an evil thing if popular feeling in this country countenances indifference to connections on which the greatness of this country arose, and to the conditions on which that greatness rests. The subjects treated in Mr. Eves's interesting paper are all of a very practical nature. As regards sugar, I ventured some years ago to express an opinion that in greater care of the cultivation, and greater attention to processes of manufacture, and in the removal of taxation on sugar production and exportation, colonists would obtain partial relief from unfair competition. Some of us have seen the exhibits shown by Mr. Morris last night, at the rooms of the Royal Society; his labours have been most useful, and we may indulge the hope that sugar cultivators will learn lessons of value from the experiments he has made and the facts he has put before them. It is satisfactory to know that improved modes of production are now being resorted to in the West Indies. We can all understand and sympathise with the feelings of discouragement which in times past have impeded resort to these measures. But it is absolutely necessary to keep up with new scientific processes, and with the requirements of the markets to which commodities are sent. Mr. Eves has done well to call attention to all the circumstances of the forthcoming Exhibition. I am particularly glad to notice that attention is about to be given to the packing of fruit; in these days business is dependent to a large extent on packing and preparing goods as they are desired to be received in different markets. These subjects are taught in foreign commercial museums. I would venture to recommend the formation of an intelligence department in connection with the forthcoming Exhibition for these objects, and to show new machines and how to work them; as well as to disseminate information in the island, and abroad, for an interchange of products. I think, too, that means might be found to open up a large trade between Jamaica and Canada. We have had a very useful discussion, and I think when the paper and discussion is circulated, it is likely to produce beneficial results. It only remains for me to ask you to pass a very cordial vote of thanks to Mr. Eves for his excellent paper.

The motion having been carried,

Mr. EVES said it had been a great pleasure to him to be allowed to bring the Jamaica Exhibition before the members of the Society of Arts, and he had to thank the members for their kind reception of the paper, and he felt sure that their support would be much appreciated in Jamaica. He wished to express his thanks to the Chairman for presiding. As the head of the commercial department of the Foreign-office, Mr. Kennedy's name was known in all parts of the world where British commerce and British influence extended, and he had taken many important parts in negotiations abroad, and it was gratifying to see that amidst his numerous duties he did not forget the Colonies. They were much indebted to that gentleman for the support he had given to the Exhibition as the representative of the Society of Arts.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JUNE 2...Royal Institution, Albemarle-street, W., 3 p.m. General Monthly Meeting, 5 p.m.

Engineers, Westminster Town-hall, S.W., 7½ p.m. Mr. Perry F. Nursey, "Pick's System of Manufacturing Salt in Vacuo."

Chemical Industry (London Section), Burlington-house, W., 8 p.m. Messrs. Cross and Bevan, "Chemistry of Hypochlorite Bleaching."

British Architects, 9, Conduit-street, W., 8 p.m. Count d'Hulst, "The Arab House in Cairo."

Victoria Institute, 1A, Adelphi-terrace, W.C., 8 p.m.

TUESDAY, JUNE 3...Royal Institution, Albemarle-street, W., 3 p m. Mr. Andrew Lang, "The Natural History of Society." (Lecture II.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Annual General Meeting.

Biblical Archæology, 9, Conduit-street, W., 8 p.m.

Zoological, 3, Hanover-square, W., 8½ p.m. 1. Mr. W. Bateson, "Cases of Repetition of Parts in Animals." 2. Mr. H. G. Smith, "Diurnal Lepidoptera on the River Aruwimi." 3. Mr. W. L. Distant, "Hemiptera." 4. Mr. H. W. Bates, "Coleoptera." 5. Mr. Herbert Druce, "New Species of Lepidoptera Heterocera."

WEDNESDAY, JUNE 4...Geological, Burlington-house, W., 8 p.m.

Cymmrodorion, 27, Chancery-lane, W.C., 8 p.m. Mr. W. Edwards, "The Settlement of Brittany."

Entomological, 11, Chandos-street, W., 7 p.m.

Royal Society of Literature, 21, Delahay-street, S.W., 1 p m.

Archæological Association, 32, Sackville-street, W., 8 p.m.

Obstetrical, 20, Hanover-square, W., 8 p.m.

THURSDAY, JUNE 5...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Mr. G. F. Scott Elliot, "Plants from Madagascar." 2. Prof. G. Henslow, "Dr. Weismann's Theory of Heredity applied to Plants." 3. Prof. B. C. A. Windle, "The Heredity of Acquired Conditions."

Chemical, Burlington-house, W., 8 p.m. Mr. C. C. Duncan, "Preparation of Pure Crystalline Copper."

Society for the Encouragement of Fine Arts, 8 p.m. *Conversazione* at the Institute of Painters in Water Colours, Piccadilly, W.

Royal Institution, Albemarle-street, W., 3 p.m. Professor Dewar, "Flame and Explosives." (Lecture V.)

Archæological Institution, Oxford-mansion, Oxford-street, W., 4 p.m.

FRIDAY, JUNE 6...Royal Institution, Albemarle-street, W., 8 p.m. Weekly meeting. 9 p.m. Prof. W. Boyd Dawkins, "The Search for Coal in the South of England."

Geologists' Association, University College, W.C., 8 p.m. Papers by Mr. H. M. Klaassen, G. F. Monckton, and H. Monckton.

Philological, University College, W.C., 8 p.m.

Quekett Microscopical Club, 20, Hanover-square, W., 8 p.m.

Physical, Science Schools, South Kensington, S.W., 5 p.m. 1. Mr. Herbert Tomlinson, "The Effect of Change of Temperature on the Critical Point of Iron." 2. Messrs. W. G. Robson and S. W. J. Smith, "The Diurnal Variation of the Magnet at Kew."

SATURDAY, JUNE 7...Royal Institution, Albemarle-street, W., 3 p.m. Rev. Baring Gould, "The Ballad Music of the West of England." (Lecture II.)

Journal of the Society of Arts.

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FRIDAY, JUNE 6, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

The Society's *conversazione* will take place at the Natural History Museum, Cromwell-road, S.W. (by permission of the Trustees of the British Museum), on Friday, 27th June.

The reception by the Duke of Abercorn (Chairman), and the members of the Council of the Society, will commence at 9.0 p.m.

The following portions of the Museum will be open :—On the Ground Floor—the Central Hall, British Saloon, Bird Gallery, and a portion of the Gallery of Fossil Mammalia ; on the First Floor—the East and West Corridors, and the Lecture Room.

The bands of the Grenadier Guards and the Scots Guards will perform during the evening.

Each member is entitled to a card for himself (which will not be transferable), and a card for a lady. In addition to this, a limited number of tickets will be sold to members of the Society, or to persons introduced by a member, at the price of 5s. each if purchased before the 14th June. After that date the price will be 7s. ; on the 27th June, 10s.

These tickets can now be purchased. They will only be supplied to persons presenting members' vouchers (which can be obtained from the Secretary) or a letter of introduction from a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter a remittance must be enclosed. Each ticket will admit one person, either lady or gentleman.

Light refreshments (tea, coffee, ices, claret cup, &c.) will be supplied.

As the number of tickets which can be issued is limited, early application is desirable. The members' tickets are now in course of issue.

Proceedings of the Society.

FOREIGN & COLONIAL SECTION.

Thursday, May 20, 1890; Sir George Birdwood, K.C.I.E., C.S.I., Member of Council, in the chair.

The paper read was—

THE INDUSTRIAL ARTS AND MANUFACTURES OF JAPAN.

By A. Lasenby Liberty.

During my three months' stay in Japan, observation convinced me that there is little to add to our technical knowledge of the Japanese industrial arts which has not already been exhaustively detailed by eminent and well-known authorities long resident in the country. Therefore, in this paper I propose to deal broadly with my subject, and to consider the race-genius of the people in connection with their industrial arts, to note how it influenced the past, and to try to form an opinion as to the extent it will affect the future.

Ethnological.—The Japanese are a distinctive and characteristic people—vigorous, tenacious, intelligent, and emotional.

(*a.*) The race has developed a simple, poetic, and euphonious language, known as the Yamoto, which, though amalgamated with, has survived the ordeal of being brought into contact with the much older and more complex language of China, compared to which it is more elastic and capable.

(*b.*) The race has evolved a high form of natural religion, known as "Shinto"—"the way of the gods"—which teaches simplicity, courtesy in social life, and careful attention to the least detail in life's surroundings. Shinto teaches the fundamental tenets of true politeness, in that it inculcates reverence to parents as one of the highest virtues, and the family circle fosters the germs of the great national trait of ceremonious politeness. There is no oath or offensive word with which to express dissatisfaction in the Japanese vocabulary, save recent acquisitions supplied by Western civilisation at the Treaty Ports

Deference to age is universal with the young; and it is considered a privilege as well as an evidence of filial duty, to study the wants and wishes of the parents even before the necessities of the progeny of those who may have households of their own. "Keep this mirror —my picture—and thy destiny will endure as long as heaven and earth" were the injunctions delivered to Jimmu-Tenno, the first Mikado, the first head of the Shinto faith, and the Shinto faith has survived both the introduction of Buddhism in the 3rd century, and Roman Catholicism in the 16th century; Buddhism adapting itself and amalgamating itself with the indigenous cult; Roman Catholicism being obliterated and swept away. The national social "Tea Ceremony," known as the "Cha-no-ya," which specially cultivates hospitality, courtesy, purity, and tranquility, comes of Shinto origin, and largely influenced the applied arts, as the rigid ceremonious rules of the "Cha-no-ya" make it compulsory on the part of every guest to bestow complimentary and minute inspection on each utensil used, and on each object and surrounding in the room. Sir Edwin Arnold attributes this influence on the arts to Buddhism, because a Buddhist priest, one "San-no-Rikin, reformed, extended, and gave the institution a dignity it had not before possessed;" but the institution was extant, or it could not have been reformed, and to ascribe the æsthetic progress of the nation to the influence of Buddhism on such grounds is surely to mix cause with effect. The architecture of the domestic buildings, and the Miyas, or temples bear witness to the Shinto spirit of simplicity and careful thoroughness, and the hearts of the people are yet imbued with the spirit of their religion. I myself saw cables, wherewith to raise the timbers of a temple in course of reconstruction, made of thick masses of human hair contributed by Japanese maids and matrons, who had voluntarily parted with their raven locks for this purpose. All the materials used for the building were gifts, the labour voluntary, and no paid craftsman engaged.

(*c*.) The race has produced an administrative Government, which, with varying fortunes, has existed during 25 centuries. The head of this Government, the present Emperor, who ceased to be known as the Mikado in 1868, ruling by right of an uninterrupted succession extending over the whole of that period. This unique dynastic continuity is surely suggestive.

Physical.—Physical causes have played no unimportant part in influencing the direction of the applied arts. The one I would especially emphasise is the liability of the islands forming the Empire of Japan to frequent seismic disturbance, necessitating the adaptation of the constructive arts to the exigencies of abnormal conditions. Thus not only are the buildings constructed in such a manner as best to resist the unwelcome but inevitable earthquake, but, the domestic buildings particularly, are planned on a most modest scale, as regards height and dimensions, and to this cause must be assigned the general "smallness" of the minor constructive arts. It would, however, be a grave error to conclude from the size of the domestic art productions that the Japanese are incapable of producing important work when materials serve, and circumstances are favourable. We have proof of this in the colossal sedant figure of Buddha of Kama-Kura, which measures 50 feet high, and weighs about 450 tons, and the bronze Buddha at Nara, through whose nostrils a grown man can pass.

Historical.—(*a*.) The earliest historical influence dates from the 3rd century, consequent on the conquest of Corea in A.D. 202 by the Empress-Regent, Jingu-Kogo. Through the medium of Corea, Japan came in contact with the language, laws, literature, and industries of China; was introduced to its more advanced culture, with Buddhism and the philosophy of Confucius and Mensius as their vehicles. Regarding Buddhism, I find much less to comment on than I anticipated; it has not so much run counter to as grafted itself on to Shintoism, the earlier cult asserting itself by method and emblem in every Buddhist shrine. The same may be said of the teachings of the Chinese sages, as a high moral code, and divine honours paid to the spirits of ancestors, famous princes, heroes, and scholars, is in strict conformity with Shinto faith. Both Buddhism and Confucianism have left deep and wide-spread traces; both are important influences; yet they have not directed, they have followed, and overlaid religion and art with a Hindu-Chinese veneer.

(*b*.) The next historical influence in order of importance was the gradual development of feudalism, dating from the beginning of the 12th century, placing a warrior, the Shogun Yorimoto, in the seat of actual power, and relegating the Mikado to a shadowy half-ecclesiastical headship. Before this period, the Mikado, in time of war, was the leader of the army, and every able-bodied man a soldier; there were no arbitrary class distinctions, and troops were disbanded after the occasion for mobilisation ceased to exist. In the year A.D. 1603, the feudal system and dual Government was perfected by the great Shogun Iyeyasu, and up to the year A.D. 1868 thenceforward the Government of Japan remained a feudal Government. The people were divided into two classes, the civil and military; the former, the Heimin, becoming serfs under vassal princes, lords, and barons; the Daimios, amongst whom the whole country was parcelled out, and the military clan, the Samurai, monopolising the entire field of arts and learning. There were in addition to these two main divisions, the Kuge, or old nobility, clustered around a shadowy court at Kiyoto with the Mikado as their centre. The capital of the Shogunate was transferred to Yedo, whither at fixed intervals the barons, accompanied by large retinues of soldiers, were bound to journey and pay homage to the reigning Shogun. These periodical ceremonious visits to the capital fostered a spirit of rivalry among the feudal chiefs, which found expression in sumptuary display. In the new capital each feudal lord, or Daimio, dwelt in his own moat-surrounded and fortified castle, and whether in his own distant province, or in the capital, employed art-craftsmen who lived under his protection, and were members of his clan. To these servant-craftsmen the Daimios looked for diversified and perfect art works, art such as might excel the possessions of rival Daimios, and in the production labour and time were deemed of no moment. It was under such exceptional circumstances that the feudal craftsmen produced the tsubas, kodzukas, menukies, armour-trappings, fine embroideries, brocades, inros, and lacquer boxes which have charmed and astonished the art critics of the Western world.

(*c.*) The introduction of Roman Catholicism in the 16th century, leading up to the expulsion of all foreigners in the 17th century, has had a greater conserving influence on the industrial arts than is generally realised. The foundation of the Jesuit order, A.D. 1542, coincided exactly with the epoch of the discovery of Japan by the Portuguese traveller Mendez Pinto, a discovery so strange that the truthfulness of his narrative was doubted, and his name, Mendez, was treated as synonymous with mendax = liar. Mendez was followed, in 1549, by the Jesuit father and missionary, Francis Xavier. In 1581, the number of Japanese converts to Roman Catholicism amounted to 150,000, with 200 churches. In 1587, to 200,000, and ultimately to 600,000, or, according to some authorities, to 2,400,000. This wonderful success was destined, however, to be short-lived. Spanish Franciscans followed the Portuguese Jesuits, and sowed discord among the converts. The Spaniards suggested to the Mikado aggressive and ambitious designs on the part of the Portuguese Government; and the Shogun became alarmed at the Papal claim to universal sovereignty. These adverse influences were stimulated by the Buddhist Bonzes, jealous counsels given by the Protestant Dutch and English, and, finally, by the imprudence and aggressive demeanour of the Romanist missionaries themselves. That the Dutch and English should have assisted in stirring up a persecution of the Christians at first sight seems incredible, but it must be remembered that it was soon after the Armada, and the fall of the Netherlands, when a Romanist was looked upon by a Protestant as more dangerous than a heathen, and it was the age of the Inquisition. Missionaries were now forbidden to preach and reside in the country, prohibitions they ostentatiously disregarded; consequently, on the 27th of January, 1614, a proclamation was issued by the Shogun Iyeyasu, which led to a general and sanguinary persecution of the converts, continued with more or less violence for twenty years, and culminating, in 1637, in armed resistance, and the destruction of 30,000 Christians. The remaining Christians, now reduced to some 30,000 or 40,000 souls, sought refuge in the province of Kiushiu, and fortified the castle of Arima, which they held for some 40 years longer, and it was not until 1677, and after a three months investment by land and water, in which Dutch cannon, it is said, co-operated, that the army of the Shogunate finally succeeded in reducing this last stronghold. The massacre which ensued baffles description. From the rocks of Papenburg thousands were hurled into the sea; all were doomed to death, and Christianity ruthlessly and absolutely stamped out. In 1624 all foreigners, with the exception of the Dutch and Chinese—and these subject to the most humiliating restrictions—were banished from the country, and an edict promulgated by Iyemidzu, which ordered the destruction of all ships of any considerable size, and limited the building of ships to certain modest dimensions, in order to prevent the Japanese henceforward from navigating the open sea, and thus coming in contact with foreign nations. This is a point to emphasize—this voluntary withdrawal of a civilised people from contact with the rest of the world, as it has fostered and nursed individuality in a manner impossible under any other conceivable circumstances. During two and a-half centuries two mighty forces—isolation and feudalism—acted in concert to confine all progress within certain limits. Within these limits there has been steady and continuous development, and so far as art, thought, and productions are concerned, the result has been of the utmost interest and (as yet only dimly realised) benefit to the sister nations of the world.

(*d.*) The latest historical event, the re-opening of Japan consequent on the arrival of Commodore Parry in the Bay of Yeddo, in 1853, was followed by a rapid absorption of western scientific and mechanical ideas and influences. Perhaps no period could have been more unfortunate for Japanese art, as it coincided with the western climax of art retrogression, and, the Japanese being an emotional people, for a while failed to discriminate between material and art advantages. But I believe the indigenous vitality of the race-genius is amending this error, and, as heretofore, will re-adapt the arts to fitly accord with altered circumstances; and this conclusion I will now endeavour to support by a survey of some of the more important industrial arts and manufactures.

Woodwork.—"The Japanese are a nation of carpenters, and with them carpentry is a fine art." So I said and felt a few days after my arrival in Japan, and this impression remains with me. I have not time to speak of woodwork in regard to the major constructive arts, the wooden temples and houses, in which the race genius for simplicity and thoroughness is most prominent, and can only allude to the minor constructive arts which are equally permeated with the same spirit, however unpretentious and humble their intended use. In cabinet work, the drawers fit so accurately, that it is a pleasure to open and shut them; the little wooden tables, the wooden trays, drinking cups, fans, tobacco-pipes, umbrella frames, bamboo baskets, buckets, ladles, implements of husbandry, &c., are all formed with rigid directness, and are artistic, each after its kind. The ordinary bamboo hand-screen or fan is a notable instance of the successful way in which the Japanese have combined the maximum of utility with the maximum of simplicity. Taking as a first hint the natural palm leaf, which is not readily obtainable in Japan, they have used a material not at first sight promising, but having the advantage of being close at hand and abundant. From this material (bamboo) and the addition of a flat surface of paper, they have contrived the most flexible, indestructible, and economic fan ever invented, which is withal built up on graceful, simple, and true constructive lines. The Japanese umbrella is a similar instance, and the original idea was doubtless borrowed from China; but how far superior in finish and taste is the Japanese development. Other instances are the bamboo baskets, known as Arima baskets, and baskets made from fern fronds at Tajema. These, and innumerable other instances which I must perforce pass over, are essentially native, essentially simple, and essentially beautiful.

Next in order is the curio-woodwork. In the example before me, a little wooden medicine box or inro, the natural bark has been advisedly left on, because the artist realised it aided the lacquer and metal ornamentation. In this, a box has been cleverly contrived by cutting the stem of a bamboo just where a horizontal division of the joint process forms a natural base. This square wooden box exemplifies the respect the Japanese pay to antiquity and quaint freedom in decoration, a combination we arbitrarily term "curio." The box is formed by adding a lid to an old rectangular Government rice-measure, so venerable that the flat iron rim which once protected its upper edges has been worn away from nearly three-quarters of its total surface. What does the artistic craftsman do under such circumstances? Does he save himself trouble and cut away the remaining projecting fragment of iron, so that he may easily make the lid fit squarely? Not at all. He honours the remaining fragment of rusty iron, and carefully cuts away the under surface of the lid just sufficiently to allow it to fit accurately over the iron. With the same thought he leaves undecorated the almost obliterated incised Government stamp found on one of the sides of this same box, and then, having retained every remaining portion of this relic of by-gone days, he proceeds to throw his own personality into the work, adding carving, and inlay of ivory, of pearl, of bronze, and of amber. These, and the thousand and one similar and familiar examples of "curios," must be conceded to be the outcome of an indigenous art.

Pictorial Art.—With the Western nations the fine arts are divorced from the applied and decorative arts, and pictorial art is, technically speaking, out of the province of this paper; and yet I do not see how it can be passed by without some word of comment, as in Japan it is the frequent custom for the artist-craftsman personally to design and manipulate every detail of his work. The pictorial art of Japan has been treated so admirably and exhaustively by Dr. Anderson, M. Gonse, and others—whose knowledge is profound, whilst my own is superficial—that I am concerned only to summarise the stages of progressive development.

The toza, or formal court school, dates from the 9th century, and exhibits a delicate rigour in outline, and a minute rendering of inanimate objects. In the 11th century the art gained greater freedom and boldness under the influence of the native yamoto or heroic school; produced, in the 12th century, a humourist or toba school; absorbed during the 14th and 15th centuries, under the name of the kano school, all that was good in the realistic teachings of China, borrowing therefrom a superlative boldness of rich and successful decorative effect, and, in the 17th century, and more particularly during the early part of this 19th century, evolved a unique popular school, in which humour, boldness, and simplicity are united.

The natural art instinct of the Japanese again and again rebelled against the formalism of their court patrons and Chinese tutors, but the nearer Japanese pictorial art approached the formal prototypes, the better it was esteemed by those who, for so many centuries, have conventionalised and fixed the art canons of Japan. For instance, Kiosai, whose death occurred during my stay in Japan, had a distinctly original genius for the portrayal of demonology, and wild imaginative delineations, and some of us are familiar with his illustrated books known as "Sketches while Drinking." He was a powerful draughtsman of the naturalistic, rapid, and vigorous full-brush-school, his life studies of crows being eminently successful, and yet he was most esteemed by his native patrons for altogether different work; work which was slavishly conventional and unimaginative, and in the old Kuge and Chinese school. The drawing before you, showing the demi-god Bishamon capturing demons, is by Kiosai.

Copies of the works of celebrated masters are used by the craftsmen engaged in the ceramic, embroidery, lacquer, and metal industries, and in many cases supplemented by natural objects, such as flowers, birds, and feathers.

The coloured print exhibited on the screen shows the debasing effect of European influence, and in contrast to this are some modern printed books in colour design, issued by the Hakubunsha Company. A third illustration shows how successfully the Japanese have adopted the art of chromo-lithography. Two other examples, books printed at the Government mills, are not inferior to the best productions of Europe. I also exhibit a *yen*, or dollar note, as a familiar instance of satisfactory modern printing and design, and some freehand drawings, specially executed for me by the talented Kyoto artist, Chickudo. From what we see of the work of modern artists, such as Sensai-Eitakku, Bairé, and Chickudo, and the printing companies, Hakubunsha, Kobunsha, and Kyushundo, we may conclude pictorial art in Japan will not retrograde, but evolve a new school, and retain, under a new phase of development whatever is good in past traditions.

Lacquer Work.—The art of the lacquer-worker is so intimately associated in our language with the word "Japan," that it has become synonymous with a specific glossy varnish; and yet the process of japanning, or lacquering, was borrowed from the Chinese. But who can look at an ordinary Japanese lacquer-tray, and compare it with the lacquer productions of the Chinese, without at once seeing that it has practically become a new invention. In Chinese work we have an opaque surface, generally ornamented with rigid, finicking, monotonous detail; in Japanese work we have a translucent surface, combined with freedom and spirit in the decorative treatment, and, as a prosaic matter of fact, far greater durability. This is true even with inferior work, which has conformed itself to the requirements of the Western demands.

But the higher branch of the lacquerer's art, which has produced the *lacquer de luxe* —an art combining the most marvellous variety in technical combination with incredible thoroughness in manipulative finish—is beyond the possibility of any comparison whatsoever. I refer, of course, to the *Hira-makiye* (flat lacquer-work), and the *Taka-makiye* (raised lacquer-work), applied to the decoration of inros, tray writing-boxes, and domestic and military furniture, during the latter decades of the feudal system. The size of these dainty examples makes it impossible to readily demonstrate this, for to be appreciated they must be closely inspected. And, here or elsewhere in this paper, when I use eulogistic terms in regard to Japanese art, I must not be understood to depreciate by comparison the classic works of Europe or Western Asia, for Japanese art is unique, and (without disparagement I would term it) a miniature art. Miniature not from lack of capability but by reason of the arbitrary causes previously alluded to.

I saw, during my stay in Tokyio and Kyoto, modern examples of the lacquerer's art which were equal to and even rivalled the choicest productions of the past, but these examples were no less costly than ancient specimens, for no such minute and thorough work can be executed without an infinite expenditure of time. The result is the same to the artist, whether he receives his remuneration in kind as a retainer and honoured craftsman in the fortress of a feudal baron, or is paid such cash remuneration as will suitably maintain him in an independent position the while he devotes his time and talent to his handicraft. Thus to those who raise loud regrets on the decadence of art in Japan, I would hint that they themselves can help to avert the evil if they are in earnest.

Ceramics.—Early Japanese ceramics do not equal early Chinese in brilliancy and translucency of colour, balanced distribution of design, or symmetry and dignity of form. And if we take examples of the old Sung, Yüen, and Ming dynasties, and compare them with old Hizen, Nabashima, Kaga, or Satsuma, this will demonstrate itself. But, as we have seen, there is an intelligent reason for this divergency; the Japanese handle and caress their little art objects, and seldom display them as permanently fixed decorative ornaments, therefore variety and interesting detail are sought after rather than broad effect. Thus the Japanese artist wanders with his pencil, just as humour leads him, above or below the surface of the object he is decorating, often placing the most careful work in such a position that, from a western standpoint, it would practically be lost; for he well knows the ceremonious and careful attention his production will secure from his countrymen, and that no quaint fancy, no one touch of his brush, will remain unappreciated. The result, in short, is not a slavish reproduction of a foreign idea, but a successful effort to fulfil the requirements of changed circumstances.

As an instance of this, I will refer to a visit I paid to a well-known potter in Kyoto, to whom a friend of mine, some twelve months previously, had entrusted one of the familiar Dresden "Nodding Mandarins," coupled with a request that this figure should be reproduced with Japanese characteristics. Apology after apology had been offered for delay, but on this occasion the artist-potter was able to show, in an unfinished state, an array of some dozen unglazed figures, the result of his experiment, each with the typical moving head and tongue of the original, but each a separate study of Japanese male or female character, and each showing individual humour and intelligence. This is the spirit in which the best masters of the present day carry out their work, but to secure work of this order one must perforce await the artist's leisure and inspiration. It is interesting to know that the more wealthy among the Japanese themselves secure the larger proportion of these higher class productions. The inferior and familiar modern ceramic wares exported in such abundance from Japan are of course regulated by the commercial law of supply and demand, and too often show a retrograde tendency.

On the question of colour pigment used in the production of modern "blue and white" wares, I pointed out to one of the most capable potters at Tokyio that the blue was crude and raw, and asked if he could not alter this to the tone of the ancient wares. His reply was to the effect that the pigment formerly used was a native form of cobalt, very difficult and tedious to manipulate; that the present substitute, obtained from Europe, could be worked much more readily, was infinitely cheaper, and that decorators had become so accustomed to use it, that he did not know where to find a man who knew the older process, or would be willing to try it, on account of the loss of time it involved.

I need hardly say that, apart from lower grade trade wares, there are excellent modern examples of Japanese ceramics sent to the Western markets, and that the works of some individual potters are of the highest merit, and evince conclusive proofs of progress.

Enamels.—In the art of *cloisonné* enamelling on copper, the Chinese attained a decorative excellence unequalled by any other nation, and the Japanese modified the art to accord with their own specific requirements, paid more regard to detail, and introduced a more sombre key of colouring. These modifications resulted in a loss of general decorative effect, but were again more in harmony with the Japanese habit of close inspection. From a Western point of view, the form of earlier Japanese enamels is unsatisfactory, but form should be judged relatively. The Japanese custom of sitting or kneeling on the floor causes a decorative object to be regarded from a different eye-level, and to arrive at a just opinion, the critic must place himself in a position similar to that in which the artist himself intended the object to be viewed. This last consideration is due also to all essentially Japanese art forms, and particularly the ceramic.

That elaborate detail and low-toned colouring can be readily departed from by the Japanese craftsman, we have proof in the rapidity with which *cloisonné* enamelling on porcelain was popularised some 15 years ago, when, under the impulse of Western suggestion; the forms were radically altered, the size of the cloisons increased, and more attention paid to bolder decorative effect. The same influence has developed a modification of *cloisonné* enamelling on copper, which promises to enjoy a greater vitality. In this process, called the "half line *cloisonné*" of Nagoya, the colours are in a higher key, shading off into many intermediate tones, the general scheme of decoration, pictorial and naturalistic, simulating the effect of bold and skilful brush work. It cannot be said that the process of enamelling on porcelain is an advance in an artistic sense, because one loses the sense of metallic durability, nor is the half line process altogether satisfactory, as it strives for pictorial effect in a material suggesting definite geometric treatment, but both processes are proofs of a ready spirit of inventiveness, and the results very far above Western production in "artistic novelties."

A quite recent advance in the enameller's art has, however, none of the foregoing objections. I refer to certain small cabinet specimens of *cloisonné* enamel on copper now being made in Kyoto and Tokyio, which are more delicate and accurate than any enamel work which the skill of any prior race or age has produced. These dainty specimens must be closely inspected in order to appreciate their freedom from mechanical spot or blemish, their delicacy of desigh, the brilliancy and beauty of their translucent colourings, and the marvel of their manipulative finish. The inventor and developer of this most exquisite diminutive art work takes so modest a view of past achievements that he explained, when we made inquiry why his signature was not attached to finished examples, that he refrained from doing so until his work reached the level of his own ideal perfection. This, surely, is the true artistic spirit, and not the least among the many fortunate omens of the art future of Japan.

(*a*) *Metal Work.* — Bronze working in Japan is a pre-historic art, bronze bells and arrow-heads being discovered concerning whose origin and age nothing is known. About the 8th century many colossal bronze figures, bells, candelabra, and incense burners were produced, designed after Chinese models for the requirements of the exotic cult of Buddhism, and no marked alteration or further progress appears to have been made in this art up to the middle of the last century, when a retrograde taste developed, also of Chinese origin, for high relief, and overgrown and overloaded ornament.

Immediately prior to European intercourse, a complete revolution took place in the bronze industry, introducing a skilful arrangement of varied metal colouring, and a better sense of due balance in ornament. In this latter school, which is absolutely indigenous, high relief does not play so prominent a part, whilst inlaying and incrustation are artistically combined with chasing and engraving. The metallic combinations — inlaying and amalgams for colour effect in modern bronzes —form an interesting and separate study.

(*b*) *The Sword.*—After the 8th century followed the era of feudalism, in which the turbulent rivalry of the barons caused the sword and armour trappings to take first rank in esteem, and the less useful bronze industry to be neglected. The art of welding steel was carried to consummate perfection, and sword blades made by such men as the Myo-chins obtained, and justly obtained, a reputation equal to the old Persian. The metal sword hilts, or *tsubas*, were treated in the utmost imaginable variety of methods consistent with utility, beauty of ornament, and the material employed. I have brought with me two specimens only, one on account of its simplicity, the granulations of the iron being utilised for the imposed decoration, and the other—a modern one, designed by Kiosai—to show that the art is not extinct. The sword blade was fitted into a wooden handle, and secured by a pin passing through a hole drilled through the iron for that purpose, and so situated and wrapped by transverse silken bands as to give the desideratum of a firm grasp to the wielder. These *menkis*, after the manner of the *tsubas*, were developed and elaborated into the most charming and varied exemplifications of the skill of the metal-worker. In fact, every portion of the sword and its belongings, the knife (*kodzuka*), the hair-pin (*ko-gai*), &c., became a detailed work of art without losing an iota of usefulness, and the Japanese sword and its fittings is in itself a type of the original, practical, and artistic genius of the nation. Western military innovations having now supplemented the sword by the breech-loader, the artist craftsmen who erewhile decorated the sword and its trappings now readily utilise their skill in other branches of the metal worker's art.

(*c*) *Iron*.—Most interesting developments in cast and wrought iron work are now produced in Tokyio and Kyoto, and an infinite variation shown in design, the inlaying of gold, silver, copper, and other metals. The Zogan-works in cast iron are coated with a steel-blue or dead-black ground work, a peculiar kind of "Nielo," which is made of lacquer putty, or Shakudo. Among the most eminent living exponents of this craft are Komi, Iyenori, and Ikokusa, and I consider the modern circular metal salver by the latter artist, which I have the pleasure to exhibit, shows breadth and force in combination, with microscopic detail, far beyond the skill of any metal-craftsman outside Japan.

The variety and beauty of Japanese iron nail heads would supply matter for a paper by itself.

(*d*) *Copper* does not lend itself well to casting, but is adapted for working up into wire and sheet forms. The Japanese fully recognise this, and utilise this property by engraving copper, and forming with it decorated mounts for boxes, cabinets, &c. The *yuwa-kashi*, or native kettle for boiling water, is an example in which the hammer marks are left on the comparative soft metal as an assistance in the decoration of the ground work: an idea happily adopted by Messrs. Tiffany, of New York, in the manufacture of silver goods.

(*e*.) *Antimony*.—The use of antimony in the manufacture of small trays and figures is quite a recent invention, promising to be very successful, and again suggestive of the ability of the Japanese to adapt their industrial arts to Western requirements. The base and main ingredient in this so-called antimony ware is lead, the surface only being hardened and fixed with antimony, and the forms suitable for paper-weights, pin-trays, &c. The designs in this ware show a marked continuity of essentially Japanese motive. Take, for instance, this little pin-tray. The motive consists of a rustic skep or basket, on which is placed, in low relief, a cock, a hen, and some chickens, and as that is all that shows when the tray is placed on a table, one would naturally suppose there was an end of it, but no, the designer, true to his native traditions, embosses beneath the tray a few grains of rice, suggesting food for fowls, and a weevil, an insect the too constant companion and destroyer of the rice. A veneer of Shakudo and Shibuitchi are added to these antimony wares, lending them colour and tone.

(*f*.) *Gold and Silver*.—In the precious metals an instructive illustration, from an artistic point of view, is the present coinage of Japan, examples of which I venture to submit, without comment, in contrast to our Jubilee coins. Formerly, the Japanese attached little value to any metal, precious or base, other than what it would produce from the art point of view, and many of their most precious heirlooms are of no intrinsic value.

Carving.—The major glyptic art was for centuries represented in Japan, by the wood-carver, the Moku-butzu, who produced life-sized and colossal figures of the various impersonations of Buddha, and the saints and heroes affiliated with the Buddhistic cult. The monotonous treatment was prescribed by formal rule, and Hindu in character. But since the disendowment of the Buddhistic fanes in 1884, this outlet for the craft has nearly ceased, the craftsmen have diverted their skill in other directions, notably in the production of natural life-sized male and female figures. I am not aware of any good examples in Europe, but the fidelity of the modern work is astonishing, and shows a knowledge and appreciation of anatomy, marred by an effort at startling realistic perfection in exaggerated accord with the Japanese spirit of thoroughness and simplicity. Others of the Moku-butzu school have turned their thoughts to commercial Western requirements. I have here a wood figure representing Ben-kei, the famous warrior and free-booter, carrying away the bell stolen from the monastery of Mi-i-dera, a popular rendering of an essentially indigenous legend, yet contrived to serve the practical purpose of a Western table-gong. This is another instance of perfect continuity combined with successful adaptation.

Passing to the minor glyptic works, we find in the class of carvings known as Netsukies, an absolutely original and indigenous art. These Netsukies, in ivory, in wood, in bone, and other materials, are so much appreciated and so well known to Western collectors, the schools and principal carvers so duly chronicled and attested, that I need here do no more than allude to them.

The immediate modern successor to the Netsukie—the Okimono—is made entirely for the Western market, and is for the most part too complex and ambitious, retaining little, if anything, of the freedom, life, and humour, the simplicity and directness of the true Netsukie. There are, however, exceptions to this rule, and I have here a modern Okimono of great beauty and interest, belonging to my friend and travelling companion, Mr. Charles Holme, which suggests the direction development will take, and that it will satisfactorily adjust itself to altered requirements. Since the partial disuse of the Netsukie, or ornamental button, through many of the Japanese adopting European costume, there are various other channels by which the old Netsukie carvers are finding an outlet for their art energies, such as the raised ivory ornamentation applied on folding-screens and cabinets, the carving of ivory parasol and umbrella handles, ivory boxes, tusks, &c. I exhibit a modern ivory box in the form of a rice bag, showing within and without a colony of rats carved in every conceivable attitude. I also exhibit an ivory tusk, engraved with monkeys by Jo-Ko-sui-Kani-nitzu. These two specimens prove what delightful work the best modern artists can produce.

Jewellery.—The jeweller's art, as applied to personal adornment, is not indigenous, save and except for the hair-pins worn by the women, and the specimens of "Japanese jewellery" with which we are now familiar in Europe are so many minor illustrations of the ready versatility of the Japanese craftsmen. This absence of desire for mere personal adornment and Spartan devotion to simplicity is very instructive, suggesting as it does a high degree of refinement and good taste. But if the pre-Europeanised Japanese could not be induced to bedeck themselves with the glitter of jewels and goldsmith's work, they were eager to bestow infinite attention to the ornamentation of the sword, the pipe, tobacco pouch, &c. To personal accessories, indeed, the goldsmith's art in Japan has heretofore been rigorously confined; and in the future it will be diverted to such progressive productions as have been alluded to under the classification of metal-work.

Embroidery.—Japanese embroidery, which is akin to, yet markedly more diversified than Chinese embroidery, is now so well known in Europe that it needs no descriptive comments. Recent influences have separated this beautiful craft into two divergent schools, in one the aim is cheapness, and the evil "sweating system" has been adopted with the inevitable results of vulgarism and deterioration; in the other, progress and a higher standard is the motto.

The Kyoto embroiderers are the best exponents of modern needlecraft, and their work mainly pictorial and naturalistic in treatment. As an exemplication of combined artistic care and skill, it would be difficult to rival the two specimens I have selected for examples, both the work of the same man, one Kobayashi. The larger of the two, the lovely impressionist view of Fuji-San from the sea coast, kindly lent by my friend, Mr. Augustus Littleton, demonstrates that perspective, and particularly aerial perspective, is an art far better understood by the Japanese than is ordinarily imagined; the design is by K. Imao, and the work so recent that I saw Kobayashi putting the finishing touches to it. The smaller example, a monkey perched on a fir tree, is after a design by Kishi, and belongs to Mrs. Liberty; and notwithstanding the design appears to be cut up into many divisions of varying materials, it is, as a matter of fact, one continuous length of white silk. The "miniature" native taste asserts itself in the border-surround; this border, which simulates applied gold brocade, consists entirely of needlework, and is a deviation from the strict rules of art, as it too successfully reproduces the mechanical regularity of a woven material, yet such a fault—the fault of a too absolute manipulative perfection, compels our admiration. The conclusion is unavoidable, that if living craftsmen produce such artistic, perfect, and versatile work as evidenced in these specimens, the vitality of the embroiderer's art in Japan is assured.

Textile Manufactures.—The most characteristic Japanese textile productions during the feudal era were silken brocades and plain stiff silken materials adapted for male and female costumes. These fabrics combined original design, sobriety, and richness of colour with excellence in quality, but the material was abnormally thick, rigid, and stiff.

One tendency of Western influence has been to reduce the substance of these silks, which was indeed thicker and heavier than seemed necessary or desirable; another to deteriorate both designs and colourings.

In contrast to the thick and stiff ceremonial silks, are the silken robes ordinarily worn by the women and children, fulfilling as they do all the requirements of a classic standard of good taste. These supple silken fabrics, both plain and craped, are generally all of one plain and quiet colour, others boldly embroidered, some printed with colour designs, some with a combination of both printing and embroidery. In passing, I would point out how skilfully, in the combination of printing and embroidering, the Japanese secure an effect as of the entire surface being covered with rich embroidery by their method of substituting printed tones and colours for the ground work, and merely touching up and emphasising certain minor portions of the design with the needlework. The result is a great saving of labour, and a hint for our own manufacturers.

Silk velvets are made in Japan of the class technically known as terry-velvets, including a remarkable variation adapted to pictorial utility. For this latter purpose, a design is painted on the silk before the pile is added, and certain parts of the pile afterwards carefully and skilfully cut down, to allow just so much of the drawing to show through as the artist judges necessary to produce either a bold or a delicate effect.

A minor branch of the silk-brocade industry produces stuffs for flat application after the manner of paper. They are used for surface decoration, mounts and borders for kakemonos, folding screens, book-covers, makimonos, and the like. Some of these thin, coarse brocades, studiously showing the uneven lines of the warp, are really very beautiful, and though an attempt has been made to introduce these and kindred characteristic native manufactures into the Western markets, no satisfactory progress has been made. I am, however, of opinion that suitable applications for Western usage will yet be found for these surface-brocades.

Of colour printing on fabrics, I have very unsatisfactory results to report. The Japanese have allowed themselves to be swamped by a huge wave of retrograde influence. I spent many unprofitable hours during my stay in Japan vainly endeavouring to select samples of printed silken fabrics which were even passable. For the moment, and, I believe, only for the moment, the Japanese colour-printer and fabric-designer has become utterly paralysed and deranged by contact with European influence. I have no time to particularise the cotton industries, but to them the same remarks equally apply.

There can be no reasonable doubt that the Japanese silk industries will in the near future greatly influence the European. Manufacturers are conforming to European requirements, the area appropriated to sericulture and the cultivation of the mulberry is being rapidly extended, the native hand-looms are being supplemented by power-looms and the latest scientific mechanical appliances of the West. The material is a home production, the workmen are industrious and deft, the cost of labour is far below the European scale, and the expense of ocean transit for an article occupying so small a bulk as manufactured silk is merely nominal. I have here samples of what is known as "gros-grain" silk, made on Japanese power-looms, which—lacking the meretricious surface lustre, and the substance produced by artificial weighting in Lyons silks at the same cost—are, as regards purity of material and prospective durability, far more satisfactory. Lyons and Milan will soon have no insignificant rival in the Japanese market.

Paper Industry.—The variety of purposes for which paper is used in Japan is not a little astonishing, including as it does such widely differing objects as overcoats, window-panes, string, and pocket-handkerchiefs. One of the most pleasing sights I ever witnessed was at the Government paper factory, at Shiebu-ogi, where we watched hundreds of intelligent little Japanese girls and women, clad in spotless white robes, preparing the Mitsumata, the bark of the paper mulberry, or dipping and arranging the snowy layers of pulp on the rectangular straining sieves. I have here a few samples of paper given me on the occasion of this visit. It has the usual characteristics, toughness and a silk-like surface. Very little paper is exported, notwithstanding its manifest excellence, as it is costly, and the cultivation of the paper-mulberry tree (cuttings of which are forbidden to be exported) is at present confined within a somewhat limited area. The present Government are bestowing great attention to the paper industries, and experimenting with pith, old silk rags, and many kinds of vegetable products. At Shiebu-Ogi, they manufacture all the chemicals used in the different processes, and the number of workers employed is quite astonishing. Paper is also made by hand labour in small quantities and varying qualities in scores of the towns and villages and, for fibrous toughness, is far superior to European paper. The excellence of certain kinds of Japanese paper for prints and etchings need not be emphasised.

From among many methods of treating paper, I will select two as examples of inventiveness, the craping of xylographic prints, by which is produced a marvellous intensity and sharpening of colour effect, and the embossing of paper leather, for tobacco pouches, bags, &c. This latter industry has been developed, under Western idfluence, into the manufacture of the "Kam-Kawa," now familiarly known as "Japanese paper leather," and used in this country and America for dados and wall-hangings. These embossed Japanese paper leathers are durable, decorative, and comparatively cheap, and there is reason to anticipate for them a steadily increased popularity. Leather-paper, as a wall covering, is, however, not used in Japan; it is essentially an adaption for export trade, and, again, an instance of the readiness of the Japanese to combine Western with native ideas.

Flower-decoration.—The arrangement of cut branches, leaves, and flowers for interior decoration, should rank among the applied arts of Japan, so carefully is the subject studied, and so charming the result obtained. It is an art with fixed canons, on which innumerable treatises are printed, long and patient courses of study are devoted—cultivated by high and low, rich and poor, and taught by regular tutors and professors. The intense love of nature innate in every Japanese, finds here a congenial form of expression which is open to dwellers in town and country alike. The highways and byeways of the cities are supplied with numerous flower markets, and places set apart for open competitions. Prizes under set rules and regulations are awarded to successful candidates, and no private or public reception takes place without the aid of a duly qualified professor being called in to arrange the inevitable floral decorations.

I suppose this subject cannot be accurately classified, but it is so intimately associated in Japan with everything connected with decoration, and so completely a part of the everyday life of the Japanese, that to ignore it would be to ignore a characteristic which proclaims its influence in every direction; it is, indeed, of very great importance in estimating the artistic character of the people, and in forming a judgment as to the direction in which we may look for the future development of the decorative and minor constructive arts—as a people permeated with so strong a love for, and appreciation of, the beauties in nature must always continue to express themselves artistically and æsthetically.

I have brought with me three diagrams taken from a number of similar instances in Mr. Josiah Conder's most instructive and interesting paper, printed in the Asiatic Society of Japan's transactions, to show the careful way in which this subject is considered and treated; one diagram even shows the relative position flower decoration should paid in regard to other interior decorative objects.

Exhibitions.—In a review of past art developments and art prospects in the future, I must not omit to bear witness to the persistent efforts of the present Japanese Government to induce their art manufacturers to conserve the spirit of past achievements. One method adopted is a free distribution among the principal craftsmen of admirable photographs of ancient and approved art examples suitable to particular industries. Some few of these photographs I had given me, and I have brought them here for inspection. Another method is the establishment in many of the cities of annual art industrial exhibitions. There are also special exhibitions held within the precincts of some one or other of the principal temples, in which the art objects are lent by amateur societies, and the particular treasures of the temple itself are displayed at these exhibitions. Foreign visitors are welcomed, but under certain reasonable restrictions.

I made the following copy of a notice posted up outside the temple of Nan-gen-ji, or Ken-nin-ji, in Kyoto (1889):—

> "The Exhibition shall be opened from 8 a.m. to 5 p.m. every day, beginning on the 6th of April to the 5th of May of the present year.
>
> "Visitors is requested at the entrance to show tickets for inspection, and should have the stamp thereon inspected.
>
> "No ticket is wanted for child, not exceeding five years of age.
>
> "Tickets are charged 10 sens [about $3\frac{1}{2}$d.], 2 sens [$\frac{3}{4}$d.], for the special and common respectively.
>
> "No visitor who is mad or intoxicated is allowed to enter in, if any person found in shall be claimed to retire.
>
> "No visitor is allowed to carry in with himself any parcel, umbrella, stick, and the like kind, except his purse, and is strictly forbidden to take in with himself dog, or the same kind of beasts.

"Visitor is requested to take good care of himself from thievely.

"Smoking is strictly forbidden in."

At the International Exhibition of 1851, when Great Britain set an example since followed by the civilised world, it first began to be realised that the inventions of science, though benefiting material prosperity, had tended to obscure and lead astray our national art instincts. In like manner, the industrial exhibitions first held in Japan after some twenty years' contact with the Western nations, revealed an immense deterioration in Japanese national art. These were the Tokyio Exhibitions of 1877 and 1881. Japan erred precisely as Great Britain had erred, and, with the far larger excuse of a restrictive past isolation, too hurriedly absorbed the scientific materialism of the West. And, as each succeeding British exhibition witnesses, we have steadily recovered lost ground and made forward progress, so the more recent Japanese exhibitions prove the Japanese are recovering and striving to carry forward the ancient spirit of their art industries.

Again, at our own International Exhibition in 1862, the art of Japan was first fully revealed to the Western world, and we should not forget the revelations of Japanese art assisted in no mean degree the Renaissance of our own minor constructive arts, and that its beneficial influence can readily be traced in our pictorial, ceramic, and decorative arts, and in improvements in our textile fabrics.

The subject of exhibitions is a most tempting one to enlarge on, and is individually interesting here, in connection with our Chairman, Sir George Birdwood, and Sir Philip Cunliffe-Owen, who stood in the van of all such enterprises; to this Society, the foster parent of exhibitions; and in view of the prospective opening of the Imperial Institute, in which H.R.H. the Prince of Wales has taken the keen and prominent interest he ever does in any scheme which makes for the benefit of the British Empire and his fellow subjects.

Conclusion.—In conclusion, I claim that the race-genius of the Japanese has preserved its individuality, known how to benefit by contact with older and seemingly more powerful foreign influences, absorbed what was useful in those influences, and evolved from them new and progressive developments, moulding even the powerful cult of Buddhism and the teaching of the Chinese sages to its own form and special requirements.

I claim that this race genius has admirably conformed itself to the peculiar physical conditions of land and climate; to historical events which, at one and the same time, fettered it in social serfdom, and barred it from all contact with the rest of the world; and that in all varying circumstances, subject only to temporary aberrations natural to an emotional people, it has maintained its essential vitality.

Therefore, for its art and industrial manufactures, I predict a renewed and progressive life, and a higher and broader perfection than was attained in a unique and historic past.

DISCUSSION.

Mr. HYDE CLARKE said he had not had the same opportunities as Mr. Liberty of acquainting himself with this subject, but he had endeavoured, from the outside, to follow it up, it being one of very great importance to art, and particularly affecting ourselves. He had listened to the paper with great pleasure, because it seemed to present the true model of a lecture upon art, whether at the Royal Academy or in that room. He referred especially to the latter part of the paper, in which Mr. Liberty stated what had been his purpose throughout. It might seem almost trivial to speak of the art genius of the population, and the local circumstances which had influenced its development; but all these circumstances, commonly called ethnological or anthropological, were really of primary importance, though they were generally wanting in English lectures on art. The influence of earthquakes on construction, and on the whole life of the population would not, probably, occur to anyone at first sight, but there was no doubt about its importance. He had lived in an earthquake country, though, fortunately, not where the movement of the earth were of almost daily occurrence, as in Japan, and had seen the necessity of adopting an altogether different system of construction to that which was found in other parts of the world. Stone buildings were reserved for public monuments, people, even of the wealthy classes, contenting themselves with houses built of wood or of common materials. In like manner the furniture was affected, and was of a very different kind to what would be expected from the wealth of the people. In such a country at any moment all the materials might be thrown down, and any light, or fire, or lamp hanging before a shrine might set fire to the building and destroy the whole contents. It became important, therefore, that even furniture and constructed appliances should be so applied as to be really useful and not dangerous. This matter, apparently trivial, went a great way to explain many of the characteristics of Japanese art. So, again, with regard to the aspect from which an object was to be regarded. Many people, like the Japanese, instead of sitting on chairs or looking at an object from an elevated position, considered it more comfortable to sit on the ground, and consequently there was a different line of sight. Sometimes one saw a work of art which had been designed as a high altar piece in a basilica in Italy, placed on a line in a picture gallery, or an object intended for a ceiling was completely spoilt in its effect by being put upon a wall. These were external conclusions, but there were many others enforced by history of equal importance. He believed the observation of the race-genius of the Japanese would fully bear out what had been stated. Comparing Japanese painting with the relics of Greek and Roman as compared with sculpture, it would be seen that while a people at a particular period may be following the traditions of a former time in one branch, they might be capable of the greatest development in other departments of art. That was certainly the case with respect to the Greeks and Romans in sculpture, and it might be that the development of the Japanese in course of time would give rise not only to the peculiar works which were now so much admired, but to works which might enter into competition with the greatest efforts of modern times.

Mr. AUMONIER asked if Mr. Liberty could give any explanation of the manner in which the peculiar effect was produced on one of the large pictures exhibited, in which the light seemed to follow a spectator as he moved about. It was a very curious effect, which he had never before seen, and it would be very interesting if some explanation could be given of how it was produced.

Mr. LIBERTY said this matter had excited a great deal of curiosity, and had been the subject of discussion many times, but up to the present he believed no explanation could be given. The Japanese were evidently fully aware, and often took advantage, of this effect, but he could not explain it.

The CHAIRMAN said he recollected two or three pictures by Russian artists in the Paris Exhibition, 1868, in which the same effect was produced.

Mr. H. STANNUS remarked that in any country liable to volcanic disturbances there could not well be stone architecture. It had been observed that where architecture was of stone there was a tendency to severity of treatment, which made itself felt in other directions also. In the stone and marble structures of Greece this severity was seen in the symmetry, both in the buildings themselves and in the ornament attached to them. In Japan there were no architectural remains, and symmetry did not appear to be sought for or encouraged. This might be observed in the diagrams of floral arrangement exhibited. In the former there was a central leaf nearly straight, and the other leaves were nearly symmetrical, and this was marked as faulty; but in the other example, which was held up as the approved model, the centre leaf was bent to one side, and the others were not so evenly balanced, which thus destroyed the symmetry. This symmetrical arrangement, as regards the identical halves, and the even distribution of ornament, were essentially academic canons in Western decorative art. Formerly, if any English student were given a panel to fill, he would first draw a straight line down the centre, and next, he would take pains to spread or "distribute" his ornament equally over the whole space. Twenty years ago it was the universal teaching, and he was glad the ridiculous idea that nothing could be artistic which was not perfectly symmetrical and evenly distributed was exploded. Japanese work had an immensely valuable educational effect in this respect, and many of our applied arts, such as paper staining, and domestic decorating generally, had been entirely re-modelled in consequence; and artists could not be too grateful to those who had brought about this improvement, and who continued to assist in it by the dissemination of Japanese works of art, among whom must be mentioned the reader of the paper.

Mr. HYDE CLARKE said in some cases the want of symmetry was governed by ethnological causes. In a true Oriental carpet you seldom found exact symmetry, and the explanation applied to many other matters. The effect was, there was a wish to avoid symmetry, which was held to be a mark of perfection, and it was unfortunate, and likely to bring the influence of the evil eye, to have anything like perfection. In fact, the common phrase for what we call the evil eye was the eye of perfection (ayn-i-kemal), and the purpose was to disenchant the object by making it imperfect.

The CHAIRMAN said it was a complete mystery to him how the Japanese could have attained to such artistic perfection. The aborigines of the country were the Ainos, and mixed up with them were Papuans, Malayans, and Chinese, all people outside the pale of historical humanity, and always looked upon as the most degraded types of the human race. It was very remarkable, therefore, that they should possess so perfect an art. Palæolithic man was indeed a better artist than neolithic; but they had always associated the highest achievements in art with the Caucasian races. The only thing to which he could liken the wonderful representations of fishes and birds exhibited by Mr. Lazenby Liberty were the paintings on the Egyptian temples, and the sculptures of the Assyrian palaces, which similarly abounded with vivid illustrations of animal and vegetable life. It might be that the Japanese having so long remained outside the pale of human history, had not been so trammelled with the traditions of ancient art, but had been left more alone with Nature, and had copied her with greater intensity. On the other hand, it occurred to him that something in Japanese art might be due to the indirect action of Assyrian tradition. M. Terrien de la Couperie had recently afforded indications of some remote connection, perhaps twenty centuries before Christ, between the civilisations of the Messopotamian valley and China, and that might partly account for at least some of the types of Japanese art. The next thing which struck him was the impassable gulf which existed between Japanese art and our own. They had very little in common, and the chief thing about the former that excited one's interest was its diabolical cleverness. He concluded by proposing a cordial vote of thanks to Mr. Liberty for giving them one of the most interesting papers he had ever heard. He had been much struck by the philosophical insight into the conditions of Japanese art which it displayed, and his only regret in presiding on the occasion was that he occupied the chair in consequence of the illness of Sir Philip Cunliffe-Owen, who had desired him to express his great regret at being absent.

The vote of thanks having been carried unanimously,

Mr. Liberty, in response, desired to express his thanks to Dr. Anderson and Mr. Moore for the very valuable specimens of Japanese art which they had lent him to illustrate the paper.

Mr. C. Purdon Clarke writes:—Mr. Liberty's paper is a valuable contribution to our knowledge of a people who may fairly be termed the most extraordinary in the world. We already knew that they stood alone of the nations of the earth in their freedom from prejudice, and in their perfect willingness to adopt anything new in which there could be found advantage; but we did not credit them with the wisdom of endeavouring to preserve at the same time all that was good in their former mode of living. The Japanese have accomplished the hardest of all tasks—a threefold revolution, religious, political, and social—and in a manner which proves them to be possessed of the highest qualities of calm judgment, combined with energy and ability to achieve. Their rapid absorption of a civilisation so opposite to their own is the more remarkable when we consider the continuity of their own form of Government, which, "with varying fortunes, has existed for twenty-five centuries," and it is to this continuity that we must ascribe the perfection arrived at in their decorative arts. Mr. Liberty's description of the art-craftsmen's social position during their feudal age—which endured from the 12th century until the middle of the 19th—recalls one brilliant, though much shorter, period in Europe, and the Daimios, each of whom "dwelt in his own moat-surrounded and fortified castle," is truly a picture of Italy in the days of the Medici. Here we have another illustration of the conditions under which all good art work in all times have been produced; the Daimio "employed art craftsmen who lived under his protection, and were members of his clan. To these servant-craftsmen the Daimios looked for diversified and perfected art works, art such as might excel the possessions of rival Daimios, and in the production labour and time were deemed of no moment." The whole paper is so rich in such suggestive matter that I should be led into writing a book in attempting to illustrate its influence on my mind; therefore, I shall conclude in congratulating Mr. Liberty generally for his instructive paper, and especially for his courage in differing from that eminent authority, Sir Edwin Arnold, who would attribute to Buddhism a beneficial influence on the arts of Japan. History tells us that the arts developed and flourished under feudalism; Buddhism is the antithesis of the splendour and pomp of feudal power, and except where Buddhist monasteries occupy the position of the feudal lords, as in Thibet to this day, the influence of this religion on the sumptuary arts is small.

Miscellaneous.

PATENTS, DESIGNS, AND TRADE MARKS.

The annual report of the Comptroller-General of the Patent-office on Patents, Designs, and Trade Marks has just appeared. It shows that since the passing of the Act of 1883, patent applications have almost continuously risen in number year by year, and that the registrations of designs have also largely increased, but not so continuously as patents.

The number of applications for patents in 1889 was 21,008. The number in 1884 was 17,110, and in 1888 19,103; so that in the single year the number has increased by nearly 10 per cent. As might be expected, a large proportion of these applications are not carried beyond the earliest stage; of the 19,103 applications in 1888, only 9,811, or, say, a half, were completed, and now remain in force, whereas under the old Act, with its higher fees, the proportion of completed patents was two-thirds. The number of applications from the United Kingdom was as follows:—England and Wales, 14,598; Scotland, 1,030; Ireland, 362; Channel Islands, 22; Isle of Man, 7—or a total of 16,019. The total number from British Colonies and possessions was 343, of which Canada takes the largest number, 100; from Europe, 2,729, of which Germany takes 1,336 and France 677; from Asia, 26; from Africa, 15; from America, 1,875, of which the United States, 1,857; and the Sandwich Islands, 1. During the year the State of Mexico joined and that of San Domingo withdrew from the Union for the protection of industrial property. The number of readers frequenting the Patent-office library during the year amounted to 88,166.

The number of designs applied for amounted to 24,370, exclusive of 335 sets of designs. This is a smaller number than in 1888, when there were 25,923 single designs applied for and 316 sets, but is a large increase on 1884, when there were 19,515 single designs and 238 sets. Six hundred and thirty-two designs were refused registration during the year on account of their similarity to designs already registered.

The total number of applications for the registration of trade marks was 11,316, a falling off from 13,315 in 1888, but a substantial increase on 1884, when they were 7,104. In the year 1889, there were 5,806 trade marks advertised and 5,053 registered.

The balance-sheet shows that the receipts from patent fees were £151,794; from designs fees, £4,833; from trade marks fees, £9,905; while the sale of publications brought £9,287; a total of £172,820. The expenses amounted to £79,286, of which the two chief items were £49,086 for salaries (all the particulars of which are given in an appendix) and £18,200 paid for printing and lithographing. The surplus for the year was £93,534 8s. 9d. The report states that a register of patent agents was established last year, and 222 agents were placed upon it up to the end of the year.

CULTIVATION OF RAMIE IN MEXICO.

In a recent report by the United States Secretary of Legation at Mexico, it is stated that Mexico offers special advantages for the successful cultivation of the ramie plant. The state of Vera Cruz is admirably adapted—from its frequent rains and facilities of irrigation in the zone which extends from Jalapa to Tuxtupec, passing through Cordoba—to the cultivation of ramie; and, in addition, the railways penetrating these districts offer ready means of transportation to market. After its second year the plant can, as it does in Venezuela, yield four, five, and even six cuttings a year. Both white and green ramie can be cultivated in Mexico, but the white is generally preferred, as it is very robust, and yields a superior fibre to the green ramie. White ramie comes from China. The leaf underneath is white, veined with green, and the leaves and stems are very hardy. Owing to this hardiness the plant will grow in almost any climate, but, nevertheless, has a predilection for a sandy, light soil, with a well-drained undersoil, as the roots rot in swampy ground. Soil impregnated with saltpetre is also prejudicial to its development. In order that the stems may grow straight and narrow, without lateral branches, it is necessary that the plants should be crowded together, having a space of not more than half-a-yard between each; the stems will then give a much superior fibre. After the second year weeding is no longer necessary, as the multiplicity of roots does not allow the growth of any parasite. Once started, the plants will last for years without being renewed. It is stated that the plants will live for more than fifty years, but to obtain this result an annual manuring is indispensable. In spite of the assertion of some cultivators that the fallen leaves suffice to manure the land, experience shows that the best results are obtained by using manure. Again, the leaves may be used for making paper, as is done in China. The cultivation of ramie requires but a small outlay and very slight labour, and, as the harvests are numerous when once the plants are fairly started, the return is prompt. It is expected that weaving and spinning mills will be established in Mexico for making use of the fibre, but it is thought that the richness of the soil will prove such that the production of raw material will far exceed their capacity of consumption, and that Europe will take any such superfluity, in preference even to hennequin. Mr. Whitehouse states that none of the machines at present in use for decortication give satisfactory results; all are too expensive, and none do sufficient work.

SILK INDUSTRY OF BROUSSA.

Broussa is one of the most flourishing commercial emporiums in the Turkish dominions. Its principal trade is in raw silk, and it has manufactures of satin, cotton cloths, carpets, tapestry, gauze and cotton twist. The trade with the interior is facilitated by caravans from Constantinople and Smyrna, that by the sea is carried on from the port of Moodania. A correspondent of a Constantinople journal, writing from Broussa, states that in that *vilayet* there are at the present time 77 spinning factories, while the centre of the silk industry is the town of Broussa itself, which contains 42 establishments. These factories employ on the average from 120 to 140 persons. All the workpeople engaged are young Mussulman, Greek, or Armenian women. The number of peasants engaged in the silk industry at Broussa amounts to about 50,000. The eggs are partly produced at home, and partly imported from France and Italy, although it is only within the last fifteen years that the importation has attained any importance. In 1888, the quantity of silk spun amounted to 133,000 kilogrammes (kilogramme = 2·2 lbs. avoirdupois), while in 1889 it amounted to 192,000 kilogrammes. All the eggs imported are examined at the School of Sericulture of Broussa, and if more than eight or nine per cent. are found to be bad the consignment is rejected. Each box costs on an average ten francs. The small farmers generally purchase an ounce of eggs, occasionally half an ounce, but rarely more than two or three ounces. All the silk spun in Broussa is exported to Europe, principally to France. Only about twelve or thirteen bales, weighing in the aggregate from 1,200 to 1,300 kilogrammes, are retained for home consumption in Broussa, and woven on the spot. The silk tissues of Broussa, so renowned for their lightness and beautiful designs, are manufactured in the various private houses. This industry is relatively very restricted, while the system of manufacture and looms employed are of the most primitive description. The weavers are generally young girls, and the tissues woven are of many descriptions. Some are made entirely of silk, while others have an admixture of cotton. It is estimated that the vilayet of Broussa contains about forty million mulberry trees. During the last three years persons previously engaged in sericulture who, being disheartened, had abandoned the industry, and devoted themselves to agricultural pursuits, have again turned their attention towards their old industry, and during the last three years alone about four million mulberry trees have been planted.

Correspondence.

MANNESMANN PROCESS FOR MAKING SEAMLESS TUBES.

In the paper read before your Society on the marvellous process of tube making by the Mannesmann process, it is stated that gunsmiths, in order to obtain fibre, adapt horsenail scrap for shot guns of good quality.

This statement may mislead. The barrels manufactured by the above process are termed Damascus, but this manufacture is very gradually becoming obsolete for the best quality of gun, being replaced by steel, and in the very highest quality gun by Whitworth's compressed fluid steel.

Careful experiments demonstrate that for tenacity and other good qualities steel far exceeds Damascus, and Damascus would ere now probably be a thing of the past were it not that, when browned, the steel band is dull and leadlike and the Damascus, consequent on the elaborate welding and working of the scrap, presents a beautiful surface.

W. A. ADAMS.

Gaines, Worcester, May 27th, 1890.

Notes on Books.

TECHNOLOGICAL DICTIONARY OF INSURANCE CHEMISTRY. By W. A. Harris. Liverpool, 1890.

The object of this work is to provide information likely to be useful to those connected with fire insurance offices, and to others who have to do with the storage or transport of inflammable materials. The information is arranged under headings, in the form of a dictionary, and is of a very miscellaneous character. There is a good deal about the more common chemical reagents, regarded from the point of view of their capability of causing or assisting combustion. Such subjects as dust in coal mines, mills, and other places where it is produced, are treated very fully, and there are also a number of miscellaneous headings referring to causes from which fires have been produced, such, for instance, as decklights and bull-eyes in windows, which it is known have acted as lenses, and set inflammable objects on fire. Even under the head of Spectacles, a case is noticed in which mischief of this sort was produced by a pair of such glasses.

MEETINGS OF THE SOCIETY.

INDIAN SECTION.

Thursday afternoon, at Five o'clock:—

JUNE 12.—SIR THEODORE C. HOPE, K.C.S.I., "The Rationale of Indian Railways." The MARQUIS OF RIPON, K.G., will preside.

MEETINGS FOR THE ENSUING WEEK.

TUESDAY, JUNE 10...Royal Institution, Albemarle-street, W., 3 p.m. Mr. Andrew Lang, "The Natural History of Society." (Lecture III.)

Medical and Chirurgical, 20, Hanover-square, W., 8½ p.m.

Photographic, 5a, Pall-mall East, S.W., 8 p.m. Mr. W. E. Debenham, "The Estimation of the Efficacy of Plate Backing."

Anthropological, 3, Hanover-square, W., 8½ p.m. 1. Mr. Theodore Bent, "The Nomad Tribes of Asia Minor." 2. Mr. Bernard Hollander, "A Contribution to a Scientific Phrenology."

Colonial Inst, Whitehall-rooms, Whitehall-place, S.W., 8 p.m. Mr. Henry Fowler, "Capital and Labour in the West Indies."

Horticultural, Drill-hall, James-street, Victoria-street, S.W., 3 p.m. Lecture.

WEDNESDAY, JUNE 11...Microscopical, 20, Hanover-square, W., 8 p.m.

Royal Literary Fund, 10, John-street, Adelphi, W.C., 3 p.m.

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m. Summer Exhibition.

United Service Inst., Whitehall-yard, S.W., 3 p.m. Surgeon William Morris, "The Transport of the Sick and Wounded in time of War."

THURSDAY, JUNE 12...SOCIETY OF ARTS, John-street, Adelphi, W.C., 5 p.m. (Indian Section.) Sir Theodore C. Hope, "The Rationale of Indian Railways."

Royal, Burlington-house, W., 8½ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Professor Dewar, "Flame and Explosives." (Lecture VI)

Mathematical, 22, Albemarle-street, W., 8 p.m.

FRIDAY, JUNE 13...United Service Inst., Whitehall-yard, S.W., 3 p.m. Mr. G. Saunders, "The Employment of Large Masses of Cavalry, of Movable Fortifications, and of Smokeless Powder, as illustrated by the late German Autumn Manœuvres."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly meeting, 9 p.m. Prof. Silvanus Thompson, "The Physical Foundation of Music."

Astronomical, Burlington-house, W., 8 p.m.

New Shakspere, University College, W.C, 8 p.m. Paper by Mr. Gollancz.

SATURDAY, JUNE 14...Royal Institution, Albemarle-street, W., 3 p.m. Rev. Baring Gould, "The Ballad Music of the West of England." (Lecture III.)

Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

Journal of the Society of Arts.

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FRIDAY, JUNE 13, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

The Society's *conversazione* will take place at the Natural History Museum, Cromwell-road, S.W., on Friday, 27th June. The reception will commence at 9.0 p.m.

The members' tickets have now been issued. Any member who has not received his should communicate with the Secretary.

A limited number of tickets will be sold to members of the Society, or to persons introduced by a member, at the price of 5s. each if purchased on or before Saturday, June 21st.* After that date the price will be 7s.; on the 27th June, 10s.

These tickets will only be supplied to persons presenting members' vouchers (which can be obtained from the Secretary) or a letter of introduction from a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter a remittance must be enclosed. Each ticket will admit one person, either lady or gentleman.

Visitors arriving or leaving by either of the Metropolitan Railways will be allowed the use of the District Company's Subway, which leads from the South Kensington Railway Station direct into the grounds of the Museum.

EXAMINATIONS, 1890.

The list of successful candidates in the Examinations for the present year has been printed, and is forwarded to the Institutions in Union with the present number of the *Journal.* Copies will also be sent to the various committees for the successful candidates.

MEDALS.

The Council have awarded the Society's Silver Medal to the following readers of papers for the Session 1889-90:—

To Armand Ruffer, M.A., M.D., for his paper on "Rabies and its Prevention."

To Arthur Paget, for his paper on "High Speed Knitting and Weaving without Weft."

To Talbot B. Reed, for his paper on "Old and New Fashions in Typography."

To William Whitaker, F.R.S., for his paper on "Coal in the South-East of England."

To Dr. J. A. Fleming, for his paper on "Prof. Elihu Thomson's Electro-Magnetic Indication Experiments."

To J. G. Gordon, for his paper on "The Mannesmann Process for making Seamless Tubes."

To Lieut.-General Sir John Stokes, K.C.B., for his paper on "The Danube and its Trade."

To A. Lazenby Liberty, for his paper on "The Industrial Arts of Japan."

To Frederick C. Danvers, for his paper on "The Records of the India-office."

To Sir Theodore C. Hope, K.C.S.I., C.I.E., for his paper on "The Rationale of Indian Railways."

To James Orrock, R.I., for his paper on "The claims of the British School of Painting to a thorough representation in the National Gallery."

To Prof. W. C. Roberts-Austen, C.B., F.R.S., for his paper on "The Use of Alloys in Art Metalwork."

Thanks were voted to the following members of Council and to the Secretary for the papers read by them:—

To Sir Robert Rawlinson, K.C.B., for his paper on "London Sewerage and Sewage."

To R. Brudenell Carter, F.R.C.S., for his paper on "Practical Vision Testing."

To Sir Douglas Galton, K.C.B., D.C.L., F.R.S., for his paper on "The Chemin de Fer Glissant, or Sliding Railway."

To Edward C. Robins, F.S.A., for his paper on "The Relation of the Fine Arts to the Applied Arts."

To H. Trueman Wood, M.A., Secretary to the Society, for his paper on "The Paris Exhibition."

Proceedings of the Society.

APPLIED ART SECTION.

Tuesday, May 13th, 1890; C. Purdon Clarke, C.I.E., in the chair.

The Secretary of the Section read the following letter from Mr. Alfred Gilbert, A.R.A.:—

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* The date has been extended from the 14th to meet the convenience of members.

MY DEAR ROBERTS-AUSTEN—I can't say how truly sorry I am at being unable to support you at your lecture.

* * * * *

You know already how deeply interested I am in the subject of the "Use of Alloys in Art Metal-work," to understand that nothing short of necessity would prevent my being present on any occasion when there should be a chance of listening to you upon the subject. Your researches and discoveries connected with the use of precious alloys by the Japanese open up to me visions of an inexhaustible wealth of suggestions for the designer for metal-work in the future. I, myself, am longing most eagerly to employ some of the wonderful tints and actual information you have given me so generously.

So much has been said of late years about texture and colour in works pertaining to the plastic art, but no suggestion, as far as I can see, for actually supplying these qualities for use in the arts in which they are most needed, viz., that of the goldsmith, have ever been made till now that you come forward with them. I jealously hope that it may fall to my lot to be the first to employ practically your discoveries, not for the sake of being first, but that by practical expression I may convey to you the best and most lasting form of gratitude for your efforts towards raising the beautiful art I love so much.

Yours, very sincerely,
ALFRED GILBERT.

The Avenue, 76, Fulham-road.
May 11, 1890.

The paper read was—

THE USE OF ALLOYS IN ART METAL-WORK.

By PROF. W. C. ROBERTS-AUSTEN, C.B., F.R.S.

A fit introduction to the kind of facts I shall have to bring before you is afforded by St. Gregory of Nyssa, who said, "How beautiful are the imitations of beautiful things, when they preserve visibly the impress of the prototype."* To deal with beauty of form in metal-work would be quite beyond me, but it may be possible to bring before you some few facts concerning the colouring and texture of metals which would, I think, present themselves to any metallurgist who might consider the matter carefully. It is usual, at the present day, to think more of the form of metal-work than either its colour or texture, but the Roman artists did not neglect either, even in the case of large works, as is shown by the description given by Pliny of a bronze statue of a dying lady, the tints of which were so arranged that the life appeared to be gradually receding from the extremities of the limbs. He also describes a metal statue in which the sculptor wished to represent cheeks suffused with blushes, a result which was obtained by inserting points of iron in the bronze, the atmospheric oxidation of the iron giving a ruddy tint to the features. Allusion has been made to these cases simply to show that special treatment of colour and texture may be applied to large monumental works, and not merely to the smaller productions to which our attention will this evening be mainly directed.

At the outset you may be inclined to question whether an effort should be made to impart colour—even natural, or apparently natural colour—to metal work, which ought to depend mainly on beauty of form. Such a view would, however, hardly survive an examination of some of the old Chinese bronzes, such as those to which I shall refer later, in South Kensington, or even the antique bronze statues, with the wide range of blues and greens, which they have attained by age and exposure to atmospheric influences. Even if you admit that colour may sometimes be advantageous, you may urge that servile imitation of the texture of one material in another cannot be legitimate art, and that point has been dealt with by Mr. Ruskin, with whose writings as a guide I have recently visited Florence, partly with this paper in view. He leads us into the church of Santa Croce, to the memorial slabs of the late 14th or middle 15th century work which adorn the pavement of the church. Many of you know well the tomb to which I refer, of which Mr. Ruskin* says:—"The old man lies on a piece of embroidered carpet, protected by the higher relief, many of the finer lines of this are almost uninjured; in particular, its exquisitely-wrought fringe and tassels are nearly perfect." And he says:—"If you kneel down and look long at the tassels of the cushion under the head, and the way they fill the angles of the stone, you will, or may, know from this example alone what noble decorative sculpture is, was, and must be from the days of earliest Greece to those of latest Italy."

Mr. Ruskin has carefully pointed out that the object of this rich adornment, and his words are the key to anything I may have to say, is merely accessory; or, to quote the learned teacher again, he says, "No great sculptor from the beginning of art to the end of it ever carved, or ever will, deceptive drapery. A man who will carve a limb or a face never finishes inferior parts, but either with a hasty or scornful chisel, or with such grave and strict selection of their lines as you know at once to be imaginative, not imitative. But if, as in this case, he wants to oppose the simplicity of his central subject with a rich background,—a labyrinth of ornamental lines to relieve the severity of the expressive ones, he will carve you a carpet, or a tree, or a rose-thicket, with fringes and leaves and thorns elaborately, as richly as natural ones, but always for the sake of ornamental form, never of the imitation, yet seizing the natural character of the lines he gives, with twenty times the precision and clearness of sight that the mere imitator has."

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* Quoted by Archdeacon Farrar, in a sermon preached at Liverpool, before the members of the National Association for the Advancement of Art, 1888.

* "Mornings in Florence, being Simple Studies in Christian Art."

We see, therefore, the way in which the imitation of material, surface, or texture may be useful as an incident of the main composition, and it is in this sense that I intend to deal with it while showing how such enrichments may be produced. I do not propose to dwell on the use of either *niello* or mere encrustations of gold, silver, or copper, which the garments of figures of bronze often received at the hands of Greek and Roman sculptors. I would consider rather the actual imitation of the surface of other materials, such as wood or fabric in metal. Examples are rare in the best work of the Italian Renaissance. In the gate of the Baptistry at Florence, Ghiberti does no more than suggest the actual texture of the fruit and flowers he uses with such perfect skill, blending them chiefly for the sake of loveliness of form. Nor, so far as I can remember, does Peter Vischer attempt to imitate the texture of leather in the metal apron of his own statue in the shrine of St. Sebald, at Nuremberg. On the other hand, in the best of the 15th and 16th century coins, which were of course not monumental work but coins, the fur and silk embroidery of the Pontifical robes are often exquisitely and naturalistically rendered. Such treatment is especially well shown in the coins of Pope Innocent XII. and Pope Alexander VIII., by Hameranus.

The Japanese, however, are the real authorities to whom we must turn for guidance in the use and treatment of alloys, both in texture and colour. First, as regards texture, they seem to delight in copying in metal-work the most delicate texture; even the bloom on the surface of fruit is not beyond their admirable skill. In tracing the nature of their methods, it is necessary to repeat what has often been said by others and by myself, respecting the alloys they employ in order to produce their wonderful results. There is a wide range of such alloys, but the principal of them are but few. There is an alloy of silver and copper, sometimes with equal proportions of precious and base metal, and there are endless varieties of copper of different degrees of purity. There are several kinds of brass, of which I cannot at present give you the analyses, because they belong to the Department of Science and Art, and will shortly be published by authority. They have also a remarkable series of alloys, in which the precious metal replaces the tin and zinc of ordinary bronze; but really their main alloys, with the exception of bronze, are comprised in the following examples.

The first is called "shaku-do;" it contains, as you will observe from Analyses I. and II.,[*]

Shaku-do.

I.

Copper	94·50
Silver	1·55
Gold	3·73
Lead	·11
Iron and Arsenic	traces
	99·89

II.

Copper	95·77
Silver	0·08
Gold	4·16
	100·01

in addition to about 95 per cent. of copper, as much as 4 per cent. of gold. It has been used for very large works. Colossal statues are made of it, one cast at Nara in the 7th century being specially remarkable. The quantity of gold is, however, very variable, and certain specimens I have analysed contain only 1·5 per cent. of the precious metal. The next important alloy used by the Japanese is called "shibu-ichi," and the following are typical analyses:—

Shibu-ichi.

III.

Copper	67·31
Silver	32·07
Gold	traces.
Iron	·52
	99·90

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[*] Analyses Nos. I. and III. are by Mr. Gowland, of the Imperial Japanese Mint at Osaka; Nos. II. and IV. by Prof. Kalischer, "Dingl. Polyt. Journ.," ccxv., 93.

IV.

Copper	51·10
Silver	48·93
Gold	·12
	100·15

There are many varieties of it, but in both these alloys, shaku-do and shibu-ichi, the point of interest is that the precious metals are, as it were, sacrificed in order to produce definite results, gold and silver, when used pure, being employed very sparingly to heighten the general effect. In the case of shaku-do, we shall see presently that the gold appears to enable the metal to receive a beautiful rich purple coat or patina when treated with certain pickling solutions, while shibu-ichi possesses a peculiar silver-grey tint of its own, which, under ordinary atmospheric influences, becomes very beautiful, and to which the Japanese artists are very partial. These are the principal alloys, but there are several varieties of them, as well as combinations of shaku-do and shibu-ichi in various proportions, as, for instance, in the case of kiu-shibu-ichi, the composition of which would correspond to one part of shaku-do rich in gold, and two parts of shibu-ichi rich in silver.

With regard to the use of pickling solutions, so far as I have been able to ascertain, they are made up respectively in the following proportions, and are used boiling:—

	I.	II.	III.
Verdigris	438 grains	87 grains	220 grains.
Sulphate of copper	292 ,,	437 ,,	540 ,,
Nitre	—	87 ,,	—
Common salt	—	146 ,,	—
Sulphur	—	233 ,,	—
Water	1 gallon	—	1 gallon.
Vinegar	—	1 gallon	5 fluid drachms.

That most widely employed is No. I. When boiled in No. III. solution, pure copper will turn a brownish red, and shaku-do, which, you will remember, contains a little gold, becomes purple. And now you will be able to appreciate the effect of small quantities of metallic impurity as affecting the colour resulting from the action of the pickle. Copper containing a small quantity of antimony gives a shade very different from that resulting from the pickling of pure copper. But the copper produced in Japan is often the result of smelting complex ores, and the methods of purification are not so perfectly understood as in the West. The result is that the so-called "antimony" of the Japanese art metal-workers, which is present in the variety of copper called "kuromi," is really a complex mixture containing tin, cobalt, and many other metals, so that a metal-worker has an infinite series of materials at command with which to secure any particular shade; and these are used with much judgment, although the scientific reasons for the adoption of any particular sample may be hidden from him. It is strictly accurate to say that each particular shade of colour is the result of minute quantities of metallic impurity, and these specimens and diagrams will, I trust, make this clear, and will prove that the Japanese arrange true pictures in coloured metals and alloys.

The action of these solutions is remarkable. You have copper to which a small amount of silver and a small amount of gold are added. The amount of gold may be variable, and artificers often take credit for putting in much more than analysis proves to be present, but a small amount of gold, it may be only one per cent., is sufficient to entirely change the character of the copper, and when you come to treat it by pickling solutions, you get a totally different result from what you would if copper alone were employed. The Japanese also take copper and dilute it, sometimes half copper and half silver, sometimes only about one-third silver and all the rest copper, and that gives the lovely series of grey alloys which, either by exposure to atmospheric influences, by handling, or by treatment of suitable pickles, gives the beautiful series of light and dark greys of which the Japanese are so particularly fond, and to which the name of shibu-ichi is given. Then again they have copper in which small amounts of impurities may be present, and the nature of such impurity and its amount, which seldom exceeds 2-10ths per cent., is quite sufficient to change the character of the copper. The Japanese, working in no small measure by rule of thumb, find that certain varieties of copper are best suited for definite processes, and they store them up and use them in a definite way. I have here a diagram which shows the particular tints produced by pure copper when adulterated, so to speak, with under two per cent. of the elements indicated—bismuth, antimony, nickel, iron, arsenic, and gold. There is also a series in which the impurity is under 2-10ths per cent., and when a pickling solution acts upon these metals you get these characteristic tints, the gold still holds its own, and produces the purple-blue alloy characteristic of the shaku-do, of which the Japanese make so much use. Remember that in all these cases the precious metals were deliberately sacrificed with a view to produce a definite result, and that is a point I want to insist upon. Why cannot we, in this country, use the alloys (of which we have the analysis here) in order to produce results in these lovely grey tints with which so many of you are familiar? The finest piece of shaku-do that I know, with its blue bloom, is this beautifully-carved sword hilt from the collection of Mr. Edward Dillon; and shaku-do forms the basis of many specimens of Japanese art. Here is a little medicine case (reproduced in a wall diagram); the base of the case is shaku-do, and, I should think, nearly of the composition given in Analysis No. 1. The enrichments are the grey shibu-ichi, a kuromi fish, with 24 tiny dots of gold in the space of about one-eighth of an inch. Then there is a shibu-ichi shell, with a gold shell placed beside it, and a kuromi carrot, on which a grey shibu-ichi mouse, with shaku-do spots let into him, is feeding. All this lavish adornment is most perfectly done. The actual method of manipulation I will now describe.

FIG. 1.

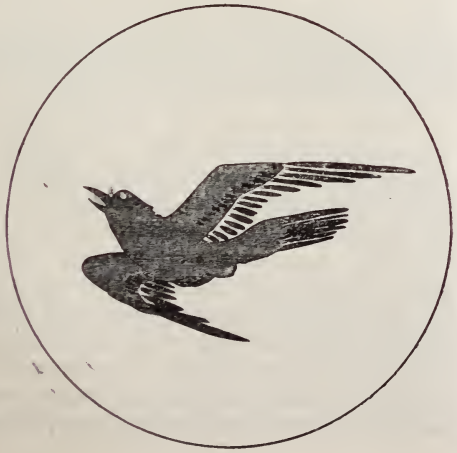
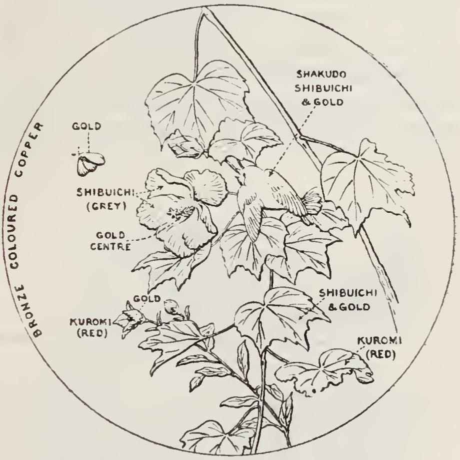


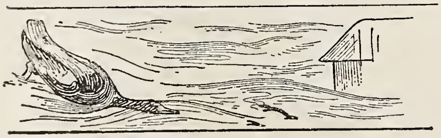
FIG. 2.



Turn to this plate of light-brown bronze (Fig. 1), which presents the simplest possible case. There is no attempt at a raised surface; the artist has simply taken a plate of bronze, $8\frac{1}{2}$ inches in diameter, he has cut a design in it, and inlaid that design with shaku-do. Wherever he has scooped out the drawing of this beautifully graceful bird, he has inlaid shaku-do; and he has taken a darker variety of shaku-do—that is to say, one which contains a little more gold which, when treated with a suitable pickling solution, will come out a little darker—and has in that way produced exactly the effect of an Indian-ink painting, in a dark and comparatively light shade, on a piece of glazed brown paper. There is no attempt at producing an effect by a raised surface, but the design is completed by an inlay of dark shaku-do on lighter shaku-do on a bronze basis. In this more precious case (Fig. 2) you have a larger plate, $18\frac{1}{2}$ inches in diameter, which is, on the whole, a fair example of the treatment of the complex series of alloys, and it has been reproduced in a wall diagram with more or less success. They first of all take a plain surface of copper. In this case there is a raised ornament, instead of a perfectly flat one. They scoop out the outline of a leaf, undercut it to a certain extent, make the leaf that they wish to insert of a particular alloy—it may be shaku-do tipped with gold, the surface being roughened and the gold hammered on just as a dentist would—then the whole design is fitted in like a puzzle, and the result is they build up a picture gradually, using coloured alloys, or alloys which may be coloured by the action of a pickle, and they attain the result which is shown in the diagram. The basis is a plate of copper. Here in one place there is a leaf which is not really raised, but a little sunk below the surface of the original plate. The only relief it possesses is obtained by hammering a light variety of gold over it. Then comes a red bud of kuromi, set with its golden points. Here is a shibu-ichi leaf, half of which is of red kuromi, and if you look closely afterwards you will see the bird, of shaku-do, with all its feathers carefully drawn, and the lustrous effect of the plumage produced with really consummate skill by the use of fine lines. Then comes a shibu-ichi flower with a golden centre. This is typical of the work they do; however large or small it may be they simply inlay these coloured alloys, using generally a sombre base.

The Japanese do not merely trust to obtaining effects by high relief, as is the case with this plate, very often they employ a darker alloy for producing the effect of painting on metal, so to speak, in a very remarkable way. There is one example in Mr. Huish's collection, a knife handle, which presents the effect of a duck's back and wings in comparatively high relief with his neck under water (Fig. 3). He is a shaku-do purple duck, plunging through silvery-grey water, but his body is in high relief, his neck is of a different *nuance*, of tinted shaku-do to the rest of his body, and it is so beautifully let in that it is only in certain lights that you can see it at all, but it produces exactly the effect of the duck's neck being below the surface of the water. I have not that specimen here, but I have in a sword-hilt, also from the collection of Mr. Huish, some tiny minnows, each about 1-16th of an inch, with minute gold eyes, swimming up a shibu-ichi grey stream, the effect of their being actually below the surface of the water being suggested with marvellous skill. I think at present no European artificer could obtain such a result as that, as it shows the most beautiful effects, not merely of texture but brilliancy and transparency. The colour effect they produce by the use of the pickles—the composition has been already given—but many of the extremely valuable old Chinese bronzes have acquired their tint simply by long exposure to atmospheric influences. If you look, for instance, at No. 160 in the South Kensington bronze cases, it is a Chinese duck of about 1 foot across, if I recollect rightly, purchased about 1876, and it has a green patina, indicating extreme old age, and although my friend, Mr. Gowland, who has recently returned from Osaka, says the attribution of it on the label to the 3rd century is inaccurate, still it is an extremely old specimen of bronze, which has acquired its green patina by perfectly natural causes, unaided by artificial treatment such as the Japanese always employ in more modern work. Again, there is No. 148, a green gourd, in the South Kensington collection, and No. 79, a vase in the form of two cups, base to base, a beautiful mottled red on a green patina, and I think in this case the red is produced by heating and not by pickling. Then if you look at No. 224 in the Museum, you will see a bronze fish with scales inlaid with silver, which is very instructive. In one of the cases, not very easily accessible, near the windows of the same Court, there are a series of specimens of bronze plaques, all modern, showing the method by which the Japanese produce their effects. Here, on the wall, is a faithful diagram of a bronze plate which has been splashed with gold; it is really hammered work, and is greyish red bronze by daylight. There is also a clouded bronze, the effect of which I think has been produced by heating and not by pickling. On this diagram (Fig. 4, p. 695) some of these effects are shown.

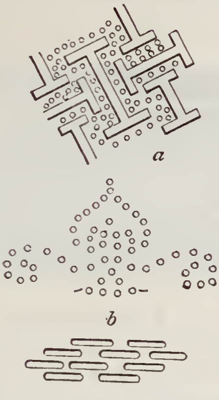
Fig. 3.



The diagram represents a portion of a Japanese knife handle in the collection of Mr. Marcus B. Huish. It consists of *Shibu-ichi*, an alloy containing about equal parts of silver and copper. The duck is of *Shaku-do*, the alloy of copper with from 1 to 5 per cent. of gold. By "pickling," a grey patina is given to the *Shibu-ichi*, and a purple patina to the *Shaku-do* duck, the arrangement being so skilful that the neck of the duck appears to be beneath the water, and is only seen when the handle is held towards the light in certain directions.

Here (*a*, Fig. 4) is a portion of an ordinary Chinese bronze kettle, in which the ornament has been obtained by little punctures from behind which reflect the light. If you looked at this you would think at first there were two metals, a copper kettle inlaid with silver, but it is nothing but the effect of the polished surface of brownish copper, with raised prominences from behind to reflect the light and produce the effect of another metal; *c*, Fig. 4, is another example of similar ornament. Mr. Gowland has lent me, for the purpose of this paper, a splendid kettle, the heating arrangements of which are intended to go inside it, a sort of double kettle. You will see how very beautifully the surface is worked, and that the effect is produced entirely without any variation of colour, for the tint is uniform throughout. Here is a characteristic brass, of which the surface is produced by simply striking it all over with a blunted tool, which gives these particular lines (*c*, Fig. 4).

Fig. 4.



But the particular alloys in which I am interested, and with which I hope to interest you, are those to which the names of moku-me (wood grain) and miyu-nagashi (marbled) are given. I have so often talked of them before, that I hesitate to describe them again. The characteristic alloys which the Japanese employ, are taken in thin sheets and soldered together—kuromi, shibu-ichi, and shaku-do—in alternate layers, as shown in the diagram (Fig. 5); then you drill conical holes, A B, in them to a greater or less depth, or roll them out, and then beat them up from behind, and then file off the prominences, C, and then beat the sheets until the holes are obliterated, and, of course, you get these different strata, and you produce these beautifully banded effects. Fig. 6 shows more accurately the method of actual work, the pattern being produced by beating up a seven-layered plate from behind, and filing the surface flat. If you look at the specimens afterwards you will see what the Japanese can do, for you have here the finest

Fig. 5.

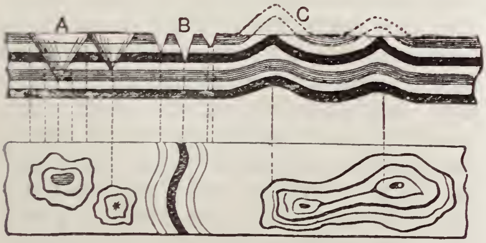


Fig. 6.

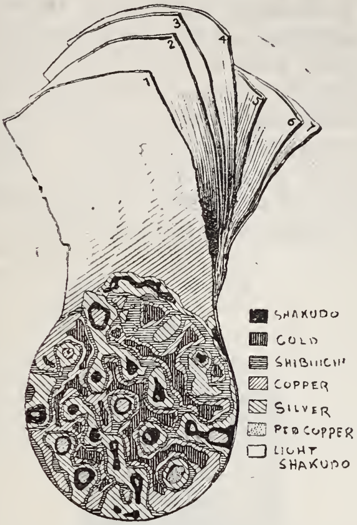
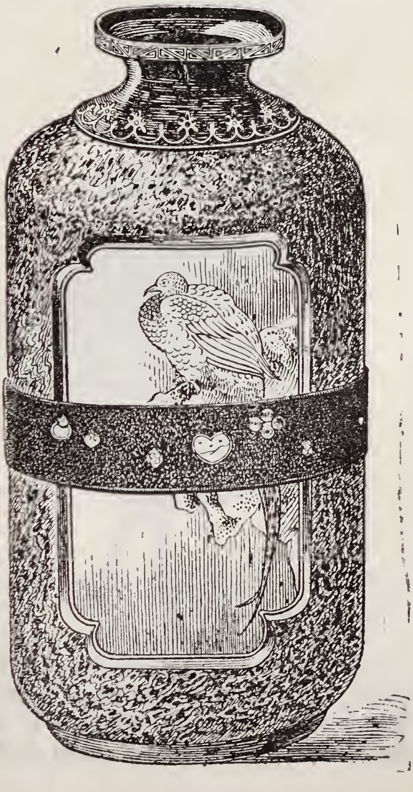


Fig. 7.



collection of moku-me ever got together. There are two vases (one shown in Fig. 7, p. 695), not very good in form, but of remarkable merit as regards the manipulative skill displayed in their production; each vase is 7 inches high. The neck-band and foot are of shaku-do inlaid with gold, while the body of the vase is of miyu-nagashi, with a silver panel bearing a bird beautifully wrought in gold and coloured alloys beaten into the silver. There are also some smaller sword-hilts and knife-handles, and a collection of beads, all remarkable examples of these banded alloys.

Fig. 8.

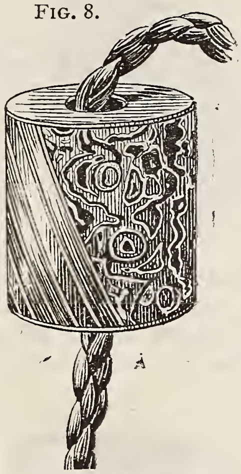
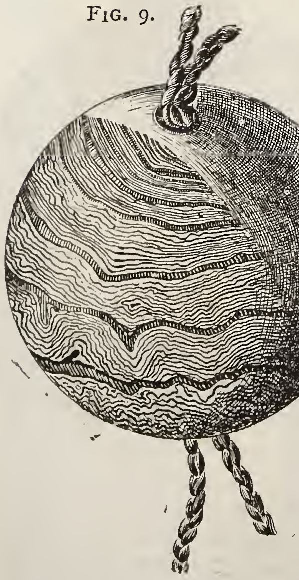


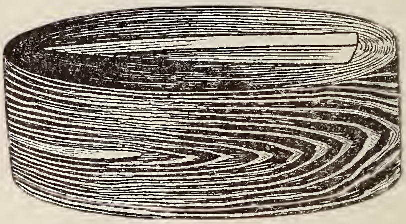
Fig. 9.



Two of these beads are shown in Figs. 8 and 9. Fig. 8 is a cylindrical bead about ½-inch high; half the cylinder is of the marbled alloy (produced as shown in Fig. 6), and the rest of the cylinder is made up of bands of red-copper shaku-do and silver, beautifully soldered. Fig. 9 represents a wonderful piece of manipulation. It is a bead 3-4ths of an inch in diameter; half the sphere is of grey shibu-ichi, and the rest is composed of very fine soldered plates, showing how perfectly the complex alloy may be worked, even into a rounded surface.

Fig. 10 represents a knife socket of alternate layers of copper and shaku-do, the effect of wood-grain (mokume) being exactly imitated.

Fig. 10.



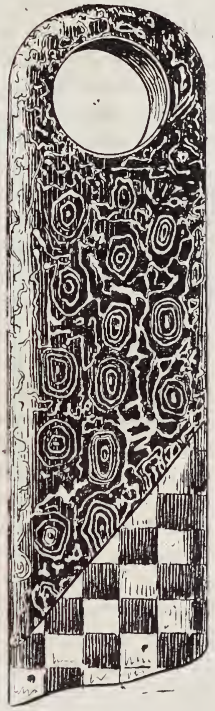
Now, so far as I know, no English artist has actually used this material with the exception of Mr. Alfred Gilbert, A.R.A., who, I rejoice to say, has employed it in the now famous chain worn by the Mayor of Preston. But it is a beautiful material, that surely must be used by English art workmen if they hope to hold their own. The Americans have adopted it already, and in the Paris Exhibition there was a very remarkable vase exhibited by Messrs. Tiffany, of New York. I have only a photograph of it here; but I have a little piece of their beautiful work in a little blade of miyu-nagashi. In the vase they exhibited the top and sides are silver, and so is the base, but the whole of the centre is of this marble alloy, produced exactly as I have indicated. This is some 29 inches high, and they asked the modest sum of £1,000 for it. They only employed five alloys, I believe, in its manufacture, but I am not certain as to the number, doubled it on themselves five times until they ultimately got 25 layers. This beautiful vase certainly constituted one of the greatest triumphs of manipulative skill the Paris Exhibition contained, and the firm were justly proud of it. Here is a little Japanese cigarette-case of copper and shakudo in many layers, in which solder cannot be detected at all, and yet it is a most complicated pattern. Messrs. Tiffany have even produced the celebrated Japanese "lobster red," which has quite eluded my efforts to secure. The lobster red of the Japanese is, I believe, not a product of pickling at all, but is cuprous oxide, formed by heating copper in air (it may be in air and steam, as is the case with their well-known and brilliant coloured commercial samples of metal), and then burnishing it, but I am not certain about it. It is easy to match anything in this plate on the table, but it is difficult to produce the true lobster red of the Japanese.

Then again, to leave Japanese art for the present, those who visited Tiffany's room in the Paris Exhibition will have seen some very beautiful alloys which showed a beautiful purple tint. They were apparently of silver, and running over the object, which was usually small, a damask pattern in a darker shade of the same purple line. There was one coffee-pot, I think some 10 inches high; this had this beautiful damask-like ornament produced apparently by inlay, but yet it was not possible to see that there was any inlay. I believe the patina in this particular case was in some way produced by the action of light. We have tried to throw some of these beautiful Japanese specimens on the screen, but I found the reflecting surfaces were too brilliant, it was impossible to succeed, and obviously we could not draw them, and therefore we must presently resolve ourselves into a committee to look at these things individually.

No texture seems to elude the skill of the Japanese. There is a knife-handle, which represents gilded leather, from Mr. Gowland's collection, and there is a sword-hilt from Mr. Dillon's collection, in which alternate layers of shaku-do and copper, some 40 of them, have been cut through so as to form a pattern, and the result is a close imitation of guri or tsui-shi lac, in the manufacture of which the Japanese are skilled. I hae seen in Mr. Dillon's collection a fish in lustrous shibu-ichi, which was so beautifully rendered that it almost suggested a marine smell. Nothing seems too difficult for the Japanese craftsman. If you look at the band round the vase, represented in Fig. 7, at first sight you would think that it was real leather. Another very subtle effect they produce is by taking merely shaku-do in thin layers and ordinary silver solder, soldering them together, and then beating them up as I have shown in the diagrams (Figs. 5 and 6), and this is their finest work. I have only one tiny fragment of it, and it is produced by the contrast of the purple shaku-do with silver solder (Fig. 11). In their very finest works they apparently use no solder a all, but simply trust to ordinary welding.

As an example of debased art, it is, perhaps, instructive to look at this article which I bought in Italy the other day; it is said to be manufactured near Milan. It is a little casket in pewter, probably marked with a revolving tool on a lathe, and the result is, that if you look at it at a little distance, it has the most ludicrous resemblance to plush or thick satin, painted with thick body-colour to represent painting on satin. It is the most frightful example of misapplied skill you can well see, still it is a close imitation of texture which might be applied to better things. Here are two little trays of quite cheap Japanese ware of copper bronze, which a botanist pronounced to be very faithful reproductions of a berried plant, and at once identified it as *Diospyros Kaki.* The skill with which the Japanese imitate the surface of the shells of crustaceans is well known, and, in fact, as I have already said, there is hardly any texture that they cannot imitate with wonderful fidelity if they care to try.

FIG. 11.

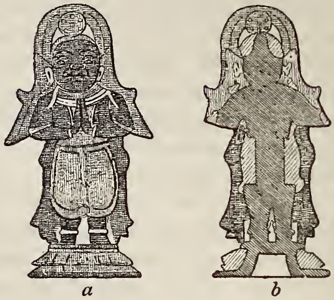


In Sir Frederick Leighton's presidential address, delivered at the Art Congress at Liverpool, he said:—"Well what, then, is our charge with respect to the present relation of the country to art? What are the shortcomings for which we are here to seek a remedy? Our charge is that with the great majority of Englishmen the appreciation of art, as art, is blunt, is superficial, is desultory, is spasmodic; that our countrymen have no adequate perception of the place of art as an element of national greatness, that they do not count its achievements among the grounds of their national pride; that they do not appreciate its vital importance in the present day to certain branches of national prosperity; that while what is excellent receives from them honour and recognition, what is ignoble and hideous is not detested by them, is, indeed, accepted and borne with a dull, indifferent acquiescence; that the æsthetic consciousness is not with them a living force, impelling them towards the beautiful and rebelling against the unsightly."

I suppose that is true as regards the majority of Englishmen, but as the President of the Royal Academy points out, real merit is acknowledged; and the enthusiasm with which any piece of metal-work of Alfred Gilbert is received, such as that grand table ornament which the army has recently given to the Queen, abundantly shows that a wide class of people will justly value really good work when they have a chance of seeing it. Anyone who has had the privilege of seeing Gilbert's recent work must really feel lost in admiration of its beauty. Even people we should think uncultivated seem to feel singular interest in the good metal work that is shown in the Arts and Crafts Exhibition. But cannot we introduce these beautiful Japanese alloys? Why is not Mr. Gardner using them? Why is it left to a metallurgist to suggest what may be done in this respect? Here they are before you, and I venture to think the metallurgists have done their part; we can tell you how to produce all these things with certainty, except, perhaps, the lobster-red, and it remains for you artists to employ them.

In conclusion, I would say that many of these alloys may be blended by casting; you may have an alloy with a solidifying point a little lower than the rest, and pour the two alloys in succession, and the one which sets first may be covered by the other one. Here is an example of a bronze god (Fig. 12) clothed in brass, with brass anklets and bracelets. That is done by pouring brass round a copper casting of suitable form. On slicing this figure through we found that was the fact. You have here the copper covered by the brass, and endless modifications may be produced in this way by pouring alloys one over the other.

FIG 12.



a b

(*a.*) Image of Hanuman in copper and brass. The dark cross lines of the section of the figure (*b*) indicate the relation of the copper core to the investing layer of brass which is marked with lighter section lines.

While this paper is passing through the press an excellent exhibition of metal work has been opened in the Hall of one of the ancient companies of the City of London—the Armourers and Braziers' Company. The works exhibited showed no lack of inventive power and careful design, notably in the case of the articles sent by the East-end "Guild and School of Handicraft," but the craftsmen limited their efforts to working in brass, copper, iron, and the precious metals, and appeared to have no notion that a wide range of beautiful alloys were equally available. Surely an effort should be made to induce British artificers to employ the materials and methods which their Japanese brethren have used for centuries with such remarkable effect.

DISCUSSION.

Mr. STARKIE GARDNER said he was not in a position to offer any critical remarks on this paper, as the use of alloys of gold and silver belonged to other branches of metal work than those with which he was connected; he did not aspire to use anything of so costly a nature. It was very lamentable that English jewellers and goldsmiths had not the same enterprise as Christofle and Tiffany had shown for many years past. As far back certainly as 1878, Christofle was introducing coloured bronzes and inlays, and Tiffany had brought them to the greatest possible perfection. Our own countrymen, even those of the greatest repute, had done nothing as far as he knew in this direction, and he supposed they must wait until some impetus was given from above. If some great personage would give a commission for a race cup or a yacht cup to be made in different alloys, no doubt it would set the fashion, and instead of wasting thousands of pounds every year in indifferent productions in silver, a part, at any rate, might be expended in works of art of this kind.

Perhaps some patron of art, when a casket or prize had to be given, would see that, instead of the old forms which had been done to death, something of this sort should be attempted. They must all be grateful to Professor Roberts-Austen for having collected such a mass of information which was quite inaccessible to most persons.

Mr. F. W. FLETCHER said he was very proud of having, under the direction of Professor Roberts-Austen, done some very successful work in moku-me or wood-grain alloy. He had worked as an experimenter in almost every alloy, and nearly every metal known to the commercial world, and, probably, a few known only to the scientific world also; but with all he had had to do with, none had interested him so much as the moku-me. He had been given to understand that the essence of art production was, that each design had its own individuality; and in this case, when you had welded or soldered several metals together, and twisted and turned them about, you could not really tell until the work was finished what the exact design would be, and it was utterly impossible to produce two pieces of this alloy exactly alike. He had been experimenting lately with the fumes of certain chemical compositions, and he was inclined to think that their action on certain metals or alloys was likely to produce better results even than the use of a solution. He had tried an experiment that evening on steel, iron, and some of the moku-me, and had brought a few rough specimens, which he should be glad to show; and if anyone were inclined to take the matter up, he should be very glad to assist him. He had been considerably disappointed several times on going to South Kensington to see the specimens he wanted, to find that they had been sent away into the country. He would ask Professor Austen if he could give any information as to the burning in of certain parts of Japanese castings, such as the fins of fishes, or spikes in dragons? There was a beautiful specimen of a dragon at Messrs. Gulley and Co.'s, in Regent-street, a short time ago, with spikes on it four or five inches long, with no sign of any solder, but they appeared to be burned in; they certainly must have been attached after the casting was made. At the same house he recently saw a very beautiful eagle, a splendid specimen of metal work, presumably Japanese. There were many alloys employed, the feathers were beautifully variegated, and it seemed to him they were made of an alloy similar to mokume; the outer edges of some of them seemed to be silver, the inner lines copper, and the middle lines of a darker colour still.

Mr. STANNUS pointed out that there was an Act of Parliament regulating the use of collections at South Kensington; it was a national collection, purchased by money from Leeds as well as elsewhere, and it was only right that people in the country should have some benefit from it. He thought it was a grand thing that the national collection was peripatetic, and that the sweetness and light which were supposed to flow from applied art were diffused through the entire country. If Mr. Fletcher lived in Leeds he would probably be very thankful for the Act of Parliament which allowed these things to go there. Professor Roberts-Austen had pointed out two principal ways in which the Japanese used their alloys; first, as coloured sculpture, so to speak; and secondly, the alloy, which was like an imitation of marble veins; and merely produced texture. The coloured sculpture was composed of shaku-do, shibu-ichi, kurowi, bronze, and so on, of which there were some interesting examples in the cases. What sculptors said about the use of colour and relief in the same object was that it was a mixing of the arts, which they strongly objected to. When the late John Gibson mixed the arts in that coloured statue, which was exceedingly beautiful, it was immediately said to be *à la* Madame Tussaud; and that one lost the value of the marble in what might as well have been coloured wax. That, of course would apply to large monumental works, but not to smaller ones, which came more under the head of goldsmith's work. There was a large field for this mixing of the arts, and now that Professor Austen, the man of science, had shown how it was to be done, it was for the men of art to use it. But though the knowledge was only young, one of our greatest English sculptors had already employed it, and probably, before long, others would follow. It was likely that in cases where hitherto the artist, in seeking for colour effects, had used enamel melted on to the surface of the metals, he would now use more of these alloys, which to his mind produced a far more beautiful and artistic effect. Enamel always seemed to have a certain artificiality about it, whereas one felt that these things were self-coloured. Imitation of texture had been deprecated, but the examples mentioned were medals—portraits of popes. Now the difference between a pope and any other man did not consist so much in his physiognomy as in his dress; hence the lace, &c., was a part of his portrait, and a means of identification, and therefore, it was perfectly natural that texture should be shown in such things when it would not be shown in monumental works. At the Italian Exhibition that kind of thing seemed to be fairly in its place in portrait busts, but directly you came to a monumental bust, the texture seemed wrong. Much of the bad work came from Milan, the most vicious school of texture sculpture in Italy, from which came the "Reading Girl;" and some of those beggars carved in marble which imitated the texture of their tattered rags were really unworthy of fine art. With regard to the second application of the mixing of alloys, as the moku-me, he should say it had a great future. It was always well to argue from the known to the unknown, from materials of which we had experience to new ones, and one might say that this metal had certain analogies to marble. Marble was a veined material, and how was it used in architecture? It was obvious it could not be used in any functional feature, in any place where a stress would come, as in the lintel of a door, because the very veining which gave the beauty of colour was also a source of weakness, as it arose from a want of homogeneity in the stone. Neither would it be used for mouldings or relief work, because the colour would have a stronger effect on the eye than the form of the moulding; hence it had become a canon in architecture that mouldings should be of plain even-grained material. But friezes, bands, and tablets, which had no carving upon them, and performed no functional duty—there was the opportunity for introducing veined marble. In the same way he should say this moku-me alloy might be used on silver, and even in wrought iron work in the decorative parts, as little choice panels and plaques. He had a friend who was very well known in the silver manufacturing trade, and he was in hopes that he would see his way to use this material, not inside the tea and coffee-pots themselves, for he thought there might be the seeds of some poisonous influence in some of these pickles, but as bands, panels, and plaques on the silver foundations. Using these metals in this way, rather for their beauty than for their value per ounce, would certainly lead to a fresh development of art work in metals. One reason why the English had been so Philistine in their development of art gold and silversmith's work, and had allowed the French and Americans to outstrip them was well illustrated in Dickens's well-known novel, in which he described a dinner party where all the plate was very solid, and seemed to proclaim to all the world that it weighed so many ounces. In point of fact the average Britisher valued his plate plainly for its weight. He had always maintained that it would be desirable to employ the finest art on the baser metals, and then there would not be the temptation to melt it down for the value of the metal. Works of art would not then disappear in the melting-pot, as so many splendid examples of mediæval art disappeared in the time of the civil wars, when some of the colleges of Oxford melted down their plate to contribute to the expenses of King Charles. Hence, if any of the art workers of this day would use some of these alloys, they would have a better chance of immortality.

Mr. FORBES ROBERTSON said he fully concurred in what had just been said as to the desirability of art being concerned not with gold or silver only but with what were generally, although erroneously, termed the baser metals. It was very curious that at a period when architecture in this country was, perhaps, at its very lowest ebb, some sort of feeling of this sort existed here, for watch chains were then made of steel, so exquisitely wrought that some sold for as much as £80. He should like to see something of the same feeling come over the spirit of the nation again. He had been much pleased at the terms in which Professor Roberts-Austen had spoken of one whom he looked upon as the first living sculptor in Europe. He was proud to think that Mr. Gilbert belonged to this country, for there had never been a man so thoroughly imbued with the real Greek spirit of sculpture. John Flaxman went a long way, but only as a sketcher and suggester, but Gilbert executed his ideas in the round. They were much indebted to Mr. Austen for revealing all these wonders of colour which were capable of being produced by the skilful manipulation of alloys. He could not imagine why we did not follow the example of Christofle and Tiffany. Both those firms did an immense business, and he remembered some very remarkable work of Christofle's coming to this country 10 or 15 years ago. One was a saint, full length, in the round, in which there were certain alloys, and the effect was wonderful when he saw it. While he rejoiced that it had been produced by that firm, he could not help feeling regret that none of our own manufacturers had done something of the same kind. He feared that, although there was as keen an artistic feeling in individual Englishmen as among any people on the Continent, yet the great bulk of our countrymen had still to be leavened by it. This was shown by the blunders made by Parliament when it attempted to lay its hand on art of any kind.

The CHAIRMAN, in putting the motion of a vote of thanks to Professor Roberts-Austen for his paper, said that as the scientific and artistic sides of the question had been so ably dealt with by Professor Roberts-Austen and the different speakers he would confine his remarks to the commercial view, except in alluding to one national characteristic of dilettanteism which led the same people who blamed Gibson for his delicate use of colour in sculpture, to bestow most rapturous admiration upon the enamelled figures of the Della Robbia school, which were often atrociously coloured. Commercially speaking, there is a great future for these Japanese methods of combining metals, either as alloys or in juxtaposition in working out various decorative forms, either on vessels or detached pieces. Whether England was to benefit or lose by this invasion of Japanese ideas was a very serious question for British manufacturers. At the Paris Exhibition of 1878, Messrs. Tiffany of New York, inflicted very considerable damage on all the European manufacturers of plate, both gold and silver, by their admirable display of art-ware in mixed metals. He (the Chairman) being officially connected with the British Section, had the privilege of taking many distinguished and royal visitors round the English and American Courts, and almost in all cases whilst only admiration was expressed for the beautiful and refined renaissance productions of Messrs. Elkington and other British firms, the same people spent money freely when they arrived at

Tiffany's Court. When purchasing at the British Section there was always the question of weight and price per ounce, but with Tiffany's rough hammered copper incrusted with silver, or silver inlaid with niello or other alloys, and encrusted with gold, such valuations by weight were obviously impossible. At that time several presentations of plate were made, and when it was desired that the money should be spent in the British Section the question of ounces always cropped up, but when a selection was made in the American Section the weight was never asked. The price was paid for the art, not for the metal, and often the workmanship in execution was not taken into account, but a high price—in comparison with the material and labour—paid for beauty of design and originality of treatment. The British manufacturer was handicapped in many ways, and, therefore, not to be blamed for what he could not help. Mixture of metals, except in the standard alloy, was in every way forbidden by law. Vessels could only be made of one metal, and could not be sold as plate unless either all gold or all silver, and on both a heavy duty was exacted before they could be offered for sale. From these restrictions the Americans are free, and at Paris, in 1878, they had the further advantage of satisfying the popular craving for novelty, and of satisfying it with something very good. Great as Messrs. Tiffany's artistic qualities were then, and since, it is a question whether their commercial foresight was not equal, if not superior. Professor Austen's allusion to the lobster-red colour attained in one of the Japanese alloys reminded him (the Chairman) of a certain lobster-red enamel used in mosaic working in Italy which, when very fine in colour, could only be procured from the excavations, as the secret of producing it had been lost. This enamel was often found in small ingots or cakes, which were cut up for use, but formerly saucers and other small vessels wereturned out from it. The paper of the evening was a valuable contribution towards furthering the work of the Society of Arts, and it would be in the future the fault of our manufacturers if no advantage was taken of the publication of the composition of these beautiful alloys, expecially as one of the vexatious restrictions—the plate duty—has now been removed.

The vote of thanks having been carried unanimously,

Professor ROBERTS-AUSTEN, in reply, said it had given him great pleasure to collect and bring forward the facts with which he had been dealing. He entirely agreed with Mr. Stannus as to the unsuitability of these alloys for monumental work, or to cases in which art was mixed, but that did not apply to such examples as he had shown, some of which consisted of perfectly flat treatment, although one alloy was inlaid upon another.

Miscellaneous.

SCIENCE AND ART DEPARTMENT.

The Lords of the Committee of her Majesty's most Honourable Privy Council on Education have issued the following information respecting the formation of classes for manual instruction (dated June 5, 1890, and signed by Major-General Donnelly):—

1. My Lords consider the minute of the rules for granting aid to drawing in elementary schools.

2. With a view to develop this instruction in a practical direction, and to assist and encourage the formation of classes for manual instruction, grants will be made by the Department of Science and Art towards the maintenance of such classes in connection with elementary schools teaching drawing under the foregoing rules; or in connection with organised science schools under Section 27 of the Science and Art Directory.

3. The instruction must be (*a*) in the use of the ordinary tools used in handicrafts in wood or iron; (*b*) given out of school hours in a properly fitted workshop; and (*c*) connected with the instruction in drawing, that is to say, the work must be from drawings to scale previously made by the students.

4. The instruction may be given by one of the regular teachers of the school if he is sufficiently qualified; if not, he must be assisted by a skilled artisan.

5. The work of the class will be examined by the local inspector of the Department, accompanied, if necessary, by an artisan expert, on the occasion of his visit to examine in drawing.

6. If it appears that the school is properly provided with plant for instruction, and that the teaching is fairly good, a grant of 6s., or, if excellent, of 7s. will be made for every scholar instructed, provided (*a*) that he has passed the 4th Standard; (*b*) that he has received manual instruction for at least two hours a week for 22 weeks during the school year; (*c*) that a special register of attendance is kept; and (*d*) that each scholar on whom payment is claimed is a scholar of the day school, and has attended with reasonable regularity. The grant may be reduced or wholly withheld at the discretion of the Department if it appears that the plant is insufficient or that the instruction is not good.

7. The managers of the school must inform the Department of Science and Art as soon as manual instruction is commenced in connection with their school.

8. If the grant be made for a period other than a year, the grant will be increased or diminished by one-twelfth for each month more or less than a year.

The following order refers to technical education:—

1. The Lords Committee of Council on Education decide, with the sanction of the Lords Commissioners

of her Majesty's Treasury, to allocate a fixed sum each year in the vote for the Science and Art Department for grants in aid of technical instruction given under the Technical Instruction Act, 1889 [52 and 53 Vict.], or under the Technical Schools (Scotland) Act, 1887 [50 and 51 Vict.].

2. The sum so allocated for the financial year 1891-92 will be £5,000.

3. The grant in aid will not necessarily be equal to, and in no case will it exceed, the amount contributed by the Local Authority out of the rates. It will be computed as far as possible on the basis of the amount of the rate spent on subjects of technical instruction other than those for which the Department gives aid under the Science and Art Directory.

4. The application from the Local Authority, which must be sent in before the end of April in each year, should therefore give a certified statement, with the necessary extracts from the accounts of the preceding year, showing how the rate raised under either of the foregoing Acts has been expended, and especially how any portion may have been applied to instruction in subjects for which grants are not made under the Science and Art Directory.

USEFUL PLANTS AND VEGETABLES IN NEW ORLEANS.

The British Consul at New Orleans has recently furnished to the Foreign Office a report on the cultivation of useful plants and vegetables. In the matter of fibrous plants it seems that the Ramie or China grass plant (*Boehmeria nivea*) has been grown with good promise of success. The plants were raised, not from seeds but from roots, which were obtained with considerable difficulty, so much so that only 85 acres were put under cultivation. The method pursued was to plough and prepare the land, taking care that the earth was well pulverised. Three ridges were formed in the way usual for sowing cotton. The ridges were 4 feet apart, and each root or piece of root from three to four inches long, and less than one inch broad, was placed in the furrow previously prepared, of about 5 inches to 6 inches deep, and 12 inches to 18 inches apart. The ridges or rows were slightly enriched with stable manure, and before a week the sprouting was distinctly seen, and before 48 hours the lines were well marked. Four months afterwards, when the growth had become rapid and the crop was 7 feet to 9 feet high and well matured for cutting, there was a severe drought of several weeks, followed by hailstorms and heavy rain, all of which the plants withstood with little or no injury. Roots planted in June were ready for cropping in October. The crop, although a first yield, was abundant, and was cut and gathered in less than 24 hours. As three crops a year in a tropical climate is a certainty, it is considered reasonable to expect two profitable crops in Louisiana. It is intended to plant at once 250 acres of the plant. With reference to the idea that Ramie would grow well in wet and undrained lands, it is stated that in Louisiana the plants perished if water remained sluggishly on the ground between the roots. The crop was taken off with difficulty in consequence of the planting having been made in ridges. It has been decided in future to plant on a dead level in rows only two feet apart, and in beds of 20, 40, or 60 feet wide, and as long as the field allows each bed to be sufficiently wide apart to allow a mowing machine with mules attached to work between them. It is confidently expected that Ramie culture will prove a profitable industry.

Jute (*Corchorus capsularis* and *C. olitorius*). The cultivation of these plants, which has been known in India for centuries, has only recently attracted the attention of the planters of the Southern States of America. In the cultivation of jute, a warm humid climate is essential to success. It will grow upon comparatively dry lands or in flooded valleys. The land intended for a jute crop must be thoroughly broken up. The time for sowing the seed varies with the condition of soil and climate; March and April are the best months for sowing, which is done broadcast from 15 lbs. to 20 lbs. to the acre. It matures in 12 weeks, and grows to the height of from 12 to 18 feet. The yield is from 3,000 to 4,000 lbs. of fibre to the acre. The plant should be cut while it is in flower, as the fibre is then more glossy. In about five weeks after flowering the plant fully ripens and the fibre then becomes woody and loses much of its commercial value.

Okra, or Ochro (*Hibiscus esculentus*). This is a well-known tropical plant belonging to the Malvaceæ, valued alike for the fibre of its inner bark and for the fresh green fruits. It is easily cultivated, and will grow on almost any soil, requires but very little attention, and when the stems are passed through a similar process as that adopted in the preparation of jute, produces a long, silky, glossy fibre. The okra is said to yield about the same amount of fibre as jute, and it is much easier to work. The fibre is useful for cordage twine, bagging, matting, upholstery work, mattresses, &c. The fruit is a highly esteemed vegetable, and is used particularly in thickening soups. Boiled okras, served with proper dressing, are said to be very palatable. The fruit forms the chief component part in the dish called "Gumbo," a name which is sometimes applied to the fruit itself. This dish is described as a highly-flavoured stew, made principally of fowl, fish, or oysters. The okra grows extensively in the West Indies. In Florida, the seed is sown late in spring in rich soil. It is said that the fruits may be preserved for winter use by cutting them in halves and hanging them up to dry. The ripened seeds, when roasted, make a good substitute for coffee.

Under the head of market gardening, it is stated that this business is very much followed at and around Pensacola, and throughout the State of

Florida, and much success attends those at Pensacola and its vicinity who follow this branch of gardening for a living. It is said that ten acres in vegetables well cultivated and properly managed will prove more profitable than a 50 acre farm producing the ordinary farm crops. A few heads of cabbage will, in good seasons, sell for as much as a bushel of corn, and a few bunches of early asparagus for as much as a bushel of wheat. Good vegetables will always sell at a good profit, and hungry cities can rarely be overstocked with them. The tomato will grow almost anywhere, and with very little trouble, and the various ways in which it can be used adds to its value. It is delicious in soups, and in many other dishes, and is canned in large quantities throughout the United States for home consumption as well as for shipment abroad. A few of the favourite varieties of the tomato grown at Pensacola are the "Acme," the "Paragon," the fruits of which are smooth, solid, of a bright crimson colour, and of excellent flavour, and very productive. The "Yellow Plum" is used for preserving, and the "Red Pear" or plum-shaped varieties which produce these fruits in clusters are the most desirable for preserving or pickling purposes.

Several varieties of the lettuce are planted in Pensacola from early spring to early summer. When np they are trimmed out to 8 inches apart, but to have good heads they must have rich soil. Among the favourite varieties in Florida are the "Early Dutch Butter," which is a celebrated and entirely distinct form, and is very popular; it produces white solid heads about equal to a cabbage. The "Improved Royal Cabbage" stands the heat and is remarkably well adapted to warm climates, or for planting to succeed early varieties. The "Drumhead Cabbage" variety is said to be quite hardy, and an excellent summer variety.

The onion does not seem to be much grown or to attain any size about Pensacola. Quantities are introduced from other places, the Western markets particularly. The onion is extensively grown in the island of Bermuda, and is shipped in large quantities, but it does not seem to be grown to any extent in any of the other British West Indian islands. Among the several varieties, the "Improved Bermuda" is highly recommended to southern cultivators by the large seed supplies of the north. Cabbages are not, as a rule, successfully cultivated at and around Pensacola; those grown do not form such large heads as those cultivated in the northern and western portions of the United States, and of which a large quantity is brought to the Pensacola market during the season. Peas and potatoes are very largely grown, but the latter are said not to attain a large size, though the quality and flavour are good.

On the subject of the sweet potato (*Ipomœa Batatas*). It is described as a leading article of food in the British West Indies, especially amongst the negroes. The tuber can be easily desiccated in the same way that peas and other fruits are dried, by slicing and exhausting it of its moisture. Like dried fruit, it will retain its saccharine, as well as its nutritious properties. It is expected that the business of drying sweet potatoes for the export trade will in due time become a profitable industry. It would probably find a market in many parts of Europe, as well as in South America. The plant may be grown so easily, cheaply, and abundantly in the southern parts of the United States, more so than in any other part of the globe, that the ramifications of an export trade in the article might be extended to embrace the uttermost parts of the earth, it being one of the cheapest of cheap and good food products.

Amongst other root crops the beet may be specially mentioned, as being specially cultivated in and around Pensacola, where it grows to a very large size, and of excellent quality.

SEA FISHERIES OF THE CANARY ISLANDS.

Fishing is the principal branch of the maritime industry of the Canary Islands. It is not carried on along the coasts of the islands, but more towards the African coast, from Cape Noun to a point rather below Cape Blanco. The portion of the coast along which are the fishing grounds is almost a desert, only inhabited by a few Arab tribes who have neither boats nor rafts. The fishermen, therefore, of the Canary Islands have, says the Belgian Consul-General at Teneriffe, nothing whatever to fear from the inhabitants of these districts. According to Kerhallet, the Canary archipelago is alive with fish, and Reclus says that in the waters surrounding the Canaries there are more fish to be found than in any other part of the ocean. The points along the coast at which fishing is carried on vary according to the seasons. In the spring and summer it is generally on the northern coast, towards Cape Noun, and even above; in autumn and winter it is, on the contrary, on the southern coast, towards Cape Blanco and below. The fishing boats thus follow in this direction the migrations of the fish. The season proper on this part of the coast is from the middle of February to the end of April, and the largest hauls are generally made near Cape Blanco. The fishing boats engaged are to the number of fifty or sixty, with an average burthen of from thirty-five to forty tons, employing about 1,200 men, and taking on the average about 7,360 tons of fish annually. Part of this fish is consumed in the islands, while the remainder is exported to Havana. Each fishing boat is calculated to hold about thirteen tons, and they are manned by a crew of from fifteen to thirty men, according to their tonnage. They make eight voyages a year, and the duration of each voyage is about a month. The expenses (the fitting-out, wages of crew, &c.) amount at the most to £120. Considerable quantities of fish are exported from the port of Las Palmas to Spain and other countries.

Among the different descriptions of fish found in the Canaries there is a considerable variety of the choicest cod, preferable, it is stated on the authority of competent persons, to that found in the northern seas of Europe and America. Large quantities of sardines and herrings are found in shoals. Among other descriptions may be mentioned the *tasartes*, fish without scales, and which, when salted and dried, strongly resembles salmon; this fish is so abundant that in good seasons the take entirely fills many of the boats. The *anjora*, a diminutive description of the above, is considered of excellent quality. The *cavallo*, which corresponds to the English horse-mackerel, is very abundant in the north. It is in between fifty and sixty fathoms of water that cod, *samos*, and *curbinas* are found; these latter are fish weighing between 20 lbs. and 30 lbs. each. In preparing the fish for market, it is gutted and dried, the head and fins cut off, and then pressed, salted, and packed in the hold. The fish prepared in this way only keeps for a short time, while if the fishermen washed and salted it a second time it would keep for six or seven months at the least. M. Allart says that if they had buildings where the fish could be dried by the sun, as, for example at Mossamedes, they could save the large quantities of salt used, and very considerably increase their profit. Prepared according to the Dutch methods, the fish of the Canary littoral would acquire a reputation and a value hitherto unknown. The boats used for fishing are very narrow fore and aft, but of considerable width in the middle, to withstand the strong winds, as it is necessary for a boat to offer considerable resistance to the latter. Part of the fish is landed at Las Palmas (Grand Canary), and the rest at Santa Cruz de Teneriffe. The price of the salted fish is from 1½d. to 2½d. a pound, and forms the staple article of food for the people. Fishing from small boats is carried on at night. The fishermen of Sainte Croix and Puerto, who are called *Chicharreros*, from a favourite fish of that name, fish at night by torch-light.

MEETINGS FOR THE ENSUING WEEK.

Monday, June 16...Geographical, University of London, Burlington-gardens, W., 2½ p.m. Annual Meeting.

British Architects, 9, Conduit-street, W., 8 p.m.

Tuesday, June 17...Gas Institute, Town-hall, Ryde, Isle of Wight, 11 a.m. Annual Meeting. Reading of papers and discussions.

Statistical, School of Mines, Jermyn-street, S.W., 7¾ p.m.

Zoological, 3, Hanover-square, W., 8½ p.m. 1. Mr. W. Bateson, "Some cases of Repetition of Parts in Animals." 2. Mr. Henley Grose Smith, "The Diurnal Lepidoptera collected by Mr. W. Bonny, of the Emin Relief Expeditions, on the River Aruwimi, Central Africa." 3. Mr. W. L. Distant, "The Hemiptera collected by Mr. W. Bonny, of the Emin Relief Expeditions, on the River Aruwimi, Central Africa." 4. Mr. H. W. Bates, "The Coleoptera collected by Mr. W. Bonny, of the Emin Relief Expeditions, on the River Aruwimi, Central Africa." 5. Mr. Herbert Druce, "Descriptions of a new Species of Lepidoptera Heterocera from Central and South America."

Wednesday, June 18...Gas Institute, Ryde, Isle of Wight, 11 a.m. Annual Meeting. Reading of papers and discussions continued.

Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Mr. William Ellis, "The Difference Produced in the Mean Temperature derived from daily Maximum and Minimum readings, as depending on the time at which the Thermometers are read." 2. Mr. W. L. Dallas, "The Distribution of Barometric Pressure at the average level of the Hill Stations in India, and its probable effect on the Rainfall of the cold weather." 3. Mr. William Ellis, "The Relative Prevalence of Different Winds at the Royal Observatory, Greenwich, 1841-1889." 4. Mr. Alex B. MacDowall, "Some Recent Variations of Wind at Greenwich."

Geological, Burlington-house, W., 8 p.m. 1. Mr. J. Postlethwaite, "The Borrowdale Plumbago, its Mode of Occurrence and Probable Origin." 2. Mr. O. A. Shrubsole, "Notes on the Valley-gravels about Reading, with especial reference to the Palæolithic Implements found there."

Microscopical, 20, Hanover-square, W., 8 p.m. Messrs. H. W. Burrows, C. D. Sherborn, and Rev. G. Bailey, "The Foraminifera of the Red Chalk of Norfolk, Lincolnshire, and Yorkshire."

National Indian Association, Westminster Palace Hotel, Victoria-street, S.W., 4½ p.m. Annual Meeting.

Thursday June 19...Royal, Burlington-house, W., 8½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Mr. M. Cresse Potter, "Observations on the Protection of Buds in the Tropics." 2. Mr. J. E. Harting, "The Distribution of the South American Bellbird belonging to the genus *Chasmorhynchus*." 3. Dr. Gustav Radde, "The Vertical Distribution of Plants in the Caucasus." 4. Mr. W. F. Kirby, "Notes on *Forficulidæ*, with descriptions of new genera and species in the British Museum."

Chemical, Burlington-house, W., 8 p.m. 1. Messrs. C. O'Sullivan and F. W. Tompson, "Invertase, a contribution to the History of an Unorganised Ferment." 2. Mr. Mond and Dr. Langer and Quincke, "The Action of Carbonic Oxide on Nickel." 3. Mr. Henry Bassett, "The interaction of Iodine, Water, and Potassium Chlorate." 4. Messrs. A. Pappel and H. D. Richmond, "The Milk of the Gamoose."

Society for the Encouragement of Fine Arts. Morning Meeting at the Oriental Institute, Maybury, Woking, Surrey, under the direction of Dr. Leitner.

Historical, 11, Chandos-street, W., 8½ p.m.

Numismatic, 22, Albemarle-street, W., 7 p.m. Annual Meeting.

Friday, June 20...United Service Inst., Whitehall-yard, 3 p.m. Lieut.-Colonel George Findlay, "The Transport of Troops by Rail within the United Kingdom"

Quekett Microscopical Club, 20, Hanover-square, W., 8 p.m.

Physical, Science Schools, South Kensington, S.W., 5 p.m. 1. Prof. A. W. Worthington, "The Stretching of Liquids." 2. Messrs. C. V. Boys, A. E. Briscoe, and W. Watson, "The Measurement of Electromagnet Radiation." 3. Dr. Gladstone and Mr. W. Hibbert, "Notes on Secondary Batteries."

Journal of the Society of Arts.

No. 1,961. Vol. XXXVIII.

FRIDAY, JUNE 20, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

FINANCIAL STATEMENT.

The following statement is published in this week's *Journal*, in accordance with sec. 40 of the Society's Bye-laws :—

TREASURERS' STATEMENT OF RECEIPTS, PAYMENTS, AND EXPENDITURE FOR THE YEAR ENDING MAY 31ST, 1890.

Dr.

	£	s.	d.	£	s.	d.
To Cash in hands of Messrs. Coutts and Co., 31st May, 1889	875	2	10			
Do. in hands of Secretary	17	1	2			
				892	4	0
,, Subscriptions received during the year from Members and Institutions in Union	5,794	6	0			
,, Life Compositions	294	0	0			
				6,088	6	0
,, Dividends and Interest				687	7	5
,, Ground Rents				319	12	4
,, Examination Fees				412	2	6
,, Advertisements				840	1	0
,, Sales, &c. :—						
Cantor Lectures	16	9	5			
Examination Papers	3	14	0			
Fees for use of meeting-room	32	11	0			
Journal	121	14	7			
Spoiled Post-cards	3	11	4			
Reports on Prime Motors Competition	21	1	0			
				199	1	4
				£9,438	14	7

Cr.

	£	s.	d.	£	s.	d.
By House :—						
Rent, Rates, and Taxes	369	3	8			
Insurance, Gas, Coal, House expenses, and charges incidental to meetings	287	19	2			
Repairs and Alterations	234	2	10			
				891	5	8
,, Office :—						
Salaries and Wages	2,051	16	3			
Stationery, Office Printing, and Lithography	277	5	7			
Advertising	77	13	6			
Postage Stamps, Messengers' Fares, and Parcels	194	19	0			
				2,601	14	4
,, Library, Bookbinding, &c.				84	15	4
,, Conversazione (1889)				400	8	8
,, *Journal*, including Printing, Stamps, and Distribution				2,154	2	1
,, Advertisements (Agents and Printing)				436	9	9
,, Examinations				422	18	0
,, Medals :—						
Albert	25	14	2			
Society's	23	7	6			
				49	1	8
,, Art Workmanship Prizes				337	18	3
,, Owen Jones Prizes				5	11	0
,, Cantor Lectures				238	6	2
,, Popular Lectures				60	0	0
,, Additional Lectures				30	0	0
,, Juvenile Lectures				25	0	0
,, Memorial Tablets				3	13	6
,, Sections :—						
Applied Art	61	6	6			
Foreign and Colonial	60	16	0			
Indian	64	5	0			
				186	7	6
,, Committees (General Expenses)				10	9	9
,, Investments :—						
Consols (Life Compositions of the year)	294	0	0			
Accumulation of Interest on Trusts placed on Deposit	50	0	0			
				344	0	0
				8,282	0	11
,, Cash in hands of Messrs. Coutts and Co., May 31st, 1890	1,144	14	7			
Do. in hands of Secretary	11	19	1			
				1,156	13	8
				£9,438	14	7

LIABILITIES.

	£ s. d.	£ s. d.
To Accounts due	444 8 11	
,, Rates	58 6 8	
,, Examiners' Fees	223 4 0	
,, Sections:—Applied Art, Foreign and Colonial, and Indian	180 0 0	
,, Accumulations under Trusts	349 8 7	
		1,255 8 2
Excess of Assets over Liabilities		16,520 5 6
		£17,775 13 8

ASSETS.

	£ s. d.	£ s. d:
By Society's Funds invested in—		
£8,124 5s. 2d. Consols, estimated at	8,002 7 9	
£500 Canada 4 per Cent. Stock, estimated at	560 0 0	
£500 South Australia 4 per Cent. Stock, estimated at	552 10 0	
£530 10s. 1d. New South Wales 3½ per Cent. Stock, estimated at	559 13 8	
£217 Great Indian Peninsula Railway 4 per Cent. Debenture Stock, estimated at	264 14 10	
£1,500 Queensland 4 per Cent. Bonds, estimated at	1,605 0 0	
£500 Natal 4 per Cent. Stock, estimated at	560 0 0	
Ground Rents	526 18 9	
		12,631 5 0
,, Subscriptions of the year uncollected	642 12 0	
,, Arrears, estimated as recoverable	200 0 0	
		842 12 0
,, Property of the Society, including Barry's Pictures and Lease of House		2,000 0 0
,, Advertisements on the Books, due and in course of execution*		795 3 0
,, Cash in hands of Messrs. Coutts and Co., 31st May, 1890		1,144 14 7
,, Do. on Deposit (including interest on Trusts)		350 0 0
,, Do. in hands of Secretary		11 19 1
		£17,775 13 8

* A portion of this sum is subject to charges for printing.

INVESTMENTS, &c., STANDING IN THE NAME OF THE SOCIETY.

	£	s.	d.
Ground Rents	£7,690	0	0
Consols	9,695	11	2
Metropolitan Railway 4 per Cent. Perpetual Preference Stock	500	0	0
Bombay and Baroda Railway 5 per Cent. Guaranteed Stock	2,450	0	0
Canada 4 per Cent. Stock	923	0	0
South Australia 4 per Cent. Stock	605	16	0
New South Wales 3½ per Cent. Stock	530	10	1
Great Indian Peninsula Railway 4 per Cent. Guaranteed Debenture Stock	2,170	0	0
Queensland 4 per Cent. Bonds	1,500	0	0
Natal 4 per Cent. Stock	500	0	0
Cash on Deposit with Messrs. Coutts and Co.	350	0	0

TRUST FUNDS INCLUDED IN THE ABOVE.

		£	s.	d.	
1.	Dr. Swiney's Bequest	£4,500	0	0	Invested in ground-rents, and chargeable with a sum of £200 once in five years.
2.	John Stock Trust	100	0	0	Consols, chargeable with the Award of a Medal.
3.	Benjamin Shaw Trust for Industrial Hygiène Prize	133	6	8	,, ,, ,, Interest as a Money Prize.
4.	North London Exhibition Trust	192	2	1	,, ,, ,, ,, ,,
5.	Fothergill Trust	388	1	4	,, chargeable with the Award of a Medal.
6.	J. Murray, in aid of a Building Fund	54	18	0	,,
7.	Subscription to an Endowment Fund	562	2	2	,,
8.	Dr. Aldred's Bequest	140	15	9	,, chargeable with the Award of a Prize.
9.	Thomas Howard's Bequest	500	0	0	Metropolitan Railway 4 per Cent. Perpetual Preference Stock, chargeable with the Award of a Prize for an Essay.
10.	Dr. Cantor's Bequest	4,600	0	0	Bombay and Baroda Railway Stock, and Ground-rents. Interest applied to the Cantor Lectures.
11.	Owen Jones Memorial Trust	423	0	0	Canada 4 per Cent. Stock, charged with the Award of Prizes to Art Students.
12.	Mulready Trust	105	16	0	South Australia 4 per Cent. Stock, the Interest to be applied to keeping Monument in repair and occasional Prizes to Art Students.
13.	Alfred Davis's Bequest	1,953	0	0	Great Indian Peninsula Railway 4 per Cent. Guaranteed Debenture Stock. Interest at the disposal of the Council for promoting the objects of the Society.
14.	Accumulated Interest on Trust Funds	349	8	7	On Deposit with Messrs. Coutts and Co.

The Assets, represented by Stock at the Bank of England, and securities, cash on deposit, and cash balance in hands of Messrs. Coutts and Co., as above set forth, have been duly verified.

B. FRANCIS COBB, } *Treasurers.*
OWEN ROBERTS, }

H. TRUEMAN WOOD, *Secretary.*

J. O. CHADWICK, F.C.A., *Auditor.*

Society's House, Adelphi, 18th June, 1890.

ANNUAL GENERAL MEETING.

The Council hereby give notice that the One Hundred and Thirty-Sixth Annual General Meeting, for the purpose of receiving the Council's Report and the Treasurers' statement of receipts, payments, and expenditure during the past year, and also for the election of officers and new members, will be held, in accordance with the Bye-laws, on Wednesday, the 25th June, at 4 p.m.

(By order of the Council)
H. Trueman Wood,
Secretary.

ALBERT MEDAL.

The Council of the Society of Arts have (with the approval of H.R.H. the Prince of Wales, the President) awarded the Albert Medal to Mr. W. H. Perkin, Ph.D., F.R.S., "for his discovery of the method of obtaining colouring matter from coal tar, a discovery which led to the establishment of a new and important industry, and to the utilisation of large quantities of a previously worthless material."

CONVERSAZIONE.

The Society's *conversazione* will take place at the Natural History Museum, Cromwell-road, S.W. (by permission of the Trustees of the British Museum), on Friday, 27th June.

The reception by the Duke of Abercorn (Chairman), and the members of the Council of the Society, will commence at 9.0 p.m.

The following portions of the Museum will be open :—On the Ground Floor—the Central Hall, British Saloon, Bird Gallery, and a portion of the Gallery of Fossil Mammalia ; on the First Floor—the East and West Corridors, and the Lecture Room.

The bands of the Grenadier Guards and the Scots Guards will perform during the evening.

Each member is entitled to a card for himself (which will not be transferable), and a card for a lady. In addition to this, a limited number of tickets will be sold to members of the Society, or to persons introduced by a member, at the price of 5s. each if purchased before the 21st June.* After that date the price will be 7s. ; on the 27th June, 10s.

These tickets will only be supplied to persons presenting members' vouchers (which can be obtained from the Secretary) or a letter of introduction from a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter a remittance must be enclosed. Each ticket will admit one person, either lady or gentleman.

Light refreshments (tea, coffee, ices, claret cup, &c.) will be supplied. No refreshments can be obtained by purchase.

As the number of tickets which can be issued is limited, early application is desirable. The members' tickets have now been issued. Any member who has not received his should communicate with the Secretary.

Visitors arriving or leaving by either of the Metropolitan Railways will be allowed the use of the District Company's Subway, which leads from the South Kensington Railway Station direct into the grounds of the Museum.

EXAMINATIONS, 1890.

The list of successful candidates in the Examinations for the present year has been printed, and can be obtained on application to the Secretary. Copies were forwarded to the Institutions in Union with last week's number of the *Journal*.

Proceedings of the Society.

INDIAN SECTION.

Thursday, June 12th, 1890 ; the Marquis of Ripon, K.G., in the chair.

The paper read was—

THE RATIONALE OF RAILWAYS IN INDIA.

By Sir Theodore C. Hope, K.C.S.I.

When I was first honoured, some weeks ago, with the invitation of the Indian Section of the Society to read a paper upon "Railways in India," my immediate feeling was that it would be quite impossible for me to say anything of interest or value upon a subject which had been so ably and exhaustively treated, only about a year ago, by Sir Juland Danvers. His essay comprises the extensions of the railway system from 1877 up to date, with details of their structure, cost, rapid execution, military or administrative value, traffic, executive agency, remunerativeness, and general prospects. It also treats of the development of trade, the routes which it tends to follow, the mercantile marine it calls into existence, the articles to which railways have been an especial boon, and the value of the whole to both Great Britain and India, in promoting the growth of wealth and the spread of civilisation. In short, the reader can rise from the perusal of that lucid and valuable paper with but one feeling paramount, namely, a hope that Sir Juland may, in the year 1899, himself be able and willing to lay before us the record of another decade. Upon ground thus effectively occupied, I felt that it would be futile and presumptuous for me to tread, and only gradually did I perceive the possibility of presenting the subject of Indian railways in two other and distinct aspects which may, possibly, be not altogether without interest to my hearers.

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* The date has been extended from the 14th to meet the convenience of members.

In the first place, I shall endeavour to explain what I call the rationale of the railways, that is, their *raison d'être*, why they are what they are, what are their relations to the country, to the people, and to each other. To do this is perhaps no very easy task, but it is easier than it would have been ten years ago, because the whole railway system has in that period become greatly enlarged and organised, and now admits of classifications of various kinds. If this treatment of the subject should prove less interesting to the general hearer than to the statesman and administrator, or if the obligation to be brief, which the limits of your leisure and patience impose, should tend to make me in any way obscure, I trust that you will extend to me your kind indulgence.

In the second place, bearing in mind the immensely increased facilities for visiting India which now exist, and the fact that a really extensive and useful tour may be made during a total absence of four or even three months from this country, I propose, in view of the artistic character of this Society, to mention rapidly some of the chief places of architectural interest which have been made readily accessible by the railway extensions of the last ten or twelve years.

The first portion of my subject, namely, the *raison d'être* of the railways as we find them, may appropriately be introduced by an examination of their alignment—that is, the routes they follow, and why those routes came to be selected. Here we may readily distinguish three phases, or eras, in the progress of railway extension between its inception in the "early fifties" and the present time, which I will term the era of trunk lines, the era of famine protection, and the era of military defence.

The era of trunk lines naturally comes first. The year 1850 opened with two companies, the East Indian and Great Indian Peninsula, under agreement to construct two short experimental portions of railway from Calcutta and Bombay respectively to the interior, but otherwise with all the most important questions involved in supplying the vast continent of India with a system of railways still under consideration between the Court of Directors and the Government of India. It is interesting and instructive to watch, in the records of the day, how intellects undoubtedly powerful dealt with problems altogether beyond previous Indian experience, and then chiefly known even in England by the practical difficulties which were there attending their solution. Thus we find gravely propounded as rigid rules that no trunk line should be constructed which had a ruling gradient steeper than 1 in 2,000, or which was estimated to cost more than £5,000 per mile, including all bridges not more than half a mile long; also, that goods and passengers should be carried in the same trains at a low speed until the net profits of the Company exceeded 6 per cent. per annum, and that whenever the traffic exceeded three trains each way a second line of rails should be added. Equally interesting is it to note how the master mind of Lord Dalhousie quietly brushed aside all such cobwebs, and raised the question out of theoretical and pedantic treatment into the higher atmosphere of political, military, and commercial expediency, tempered by common sense.* Grasping the fact that India's primary need was a few great trunk lines, connecting the various presidencies or distinct portions of the empire, and suitable as arteries with which minor lines, covering the surface of India, might hereafter be connected as occasion required, he took it as an obvious corollary that these trunk lines should have the most favourable gradients, and should be constructed and worked in the most economical manner which could possibly be secured for them.

First in order of importance and value Lord Dalhousie designated the line from Calcutta, by the Ganges valley, to the North-West Provinces, and onward to Lahore and Jhelum, to be prolonged to Attock whenever convenient. Enumerating in thoughtful detail its military value in times alike of peace and war, its beneficial effect upon agriculture, population, the opium districts, the coal and other mineral wealth, and the general interests of trade, he pronounced it "a very noble work, replete with the highest advantages to the Government and the public."

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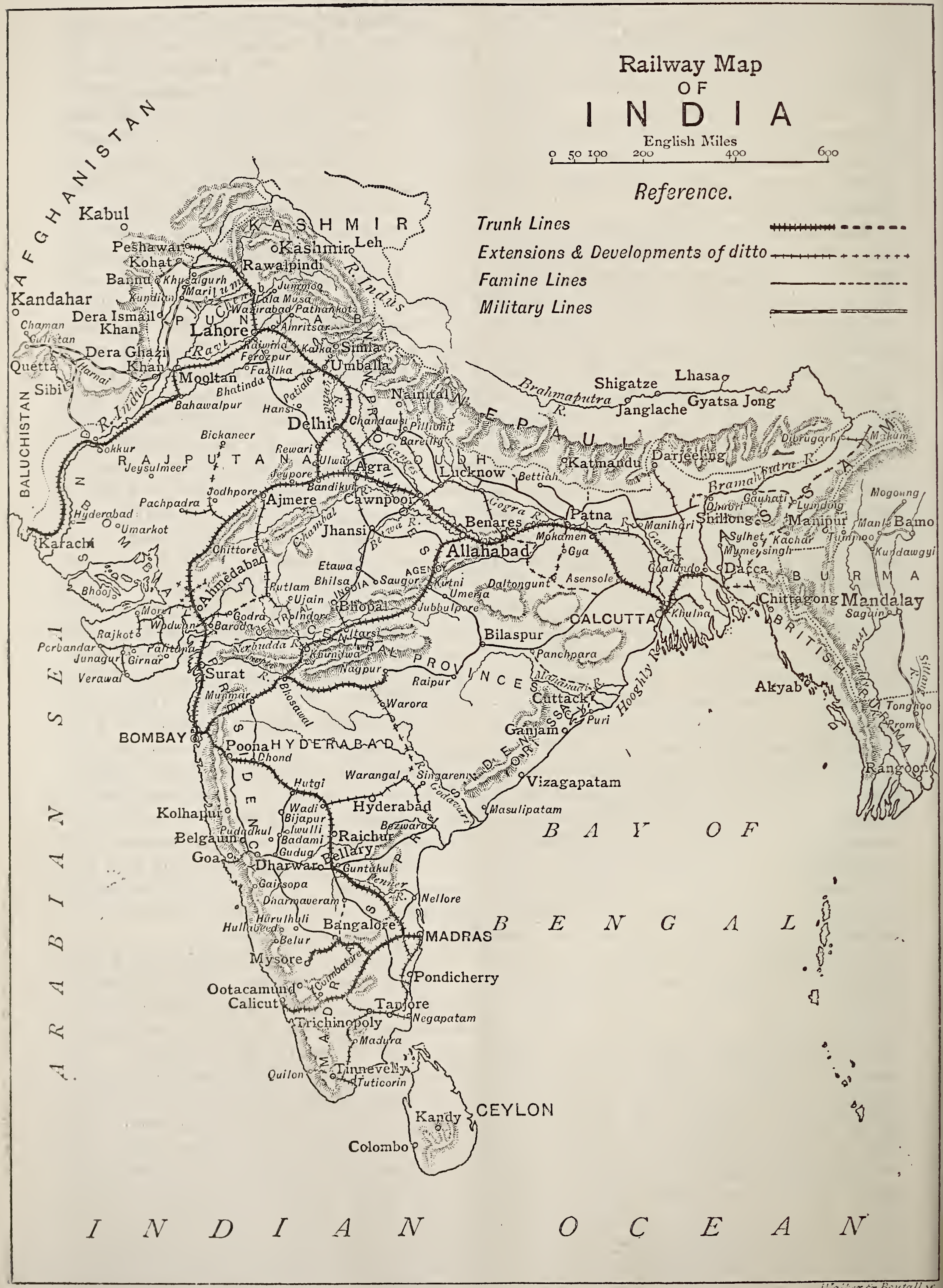
* Minute, dated 20th April, 1853.

Next, he declared "some line uniting Hindustan with Bombay" to be immediately desirable. Here his remarks are highly interesting when read by the light of subsequent events. Carefully examining the rival projects *viâ* Surat, Baroda, and Neemuch to Agra, and *viâ* the Nerbudda or Taptee valleys, or the Thull Ghat, to join at Mirzapore the East Indian Railway to Calcutta, he held that both would ultimately be made, but that if one only was at first obtainable, the former was the more advantageous, supposing surveys to prove it practicable. Curiously enough, the Bombay Government and community were at that time blind to the advantages which direct communication with Upper India would afford to them; the feeling was in favour of early access to their own plateau and Calcutta. This feeling, coupled with Lord Dalhousie's recognition of the local usefulness of a line from Bombay to Khandaish, with the eagerness of the East Indian Railway to branch off towards Bombay, and possibly, with their jealousy of an intruder into their monopoly of Upper India, led to his decision being set aside, notwithstanding that investigation established the practicability and cheapness of the Rajputana route. Later on, when the Bombay Government and merchants had discovered their mistake, they for years pleaded in vain for the direct line to Hindustan, and in the end received it in only a maimed and disadvantageous form.

As to Madras, Lord Dalhousie decided that connection with Bombay was its chief want, for military no less than commercial purposes, and that this connection should be by Bellary, Sholapur, and Poona, rather than by the Godavery on the one hand, or the west coast on the other, routes then advocated on grounds which, in the present day, appear little less than fanciful. A second trunk line from Madras, by Arcot, Vellore, Salem, and Coimbatore, to Calicut on the west coast, with a branch to Bangalore, was approved in order to open up Southern India.

The whole of Lord Dalhousie's great project was, in the end, carried out, but with very considerable delay. The East Indian did not reach Delhi till 1864, or join hands at Jubbulpur with the Great Indian Peninsula until 1870, and the latter did not meet the Madras railway at Raichore until 1872; Lahore was only attained in 1871, and Attock in April, 1881; while the direct communication between Bombay and Hindustan *viâ* Rajputana, which he had deemed so important, was not effected for nearly thirty years, until January, 1881, notwithstanding the great warnings of the Mutiny and the Rajputana famine. The furnishing of India with trunk lines, however, did not end with Lord Dalhousie's broad initiatory sketch. In 1855, the commencement was made, under his own auspices, of a trunk line between the Punjab and Sind, starting with the connection of Karachi and Hyderabad (Kotri) in Sind; in 1859 this undertaking was expanded by a railway from Umritsar, *viâ* Lahore, to Multan, and a steam flotilla thence to Hyderabad. Some ten years later, the connection of Multan and Hyderabad by railway was approved, though with a hesitancy and pessimism which, at this distance of time, it is difficult to account for. Again, 1858 saw the sanction of the Eastern Bengal Railway, from Calcutta to Dacca; and 1881 the commencement of the line from Rangoon to Tonghoo, which has become the trunk line for Burma, now entirely British. Finally, in 1887, the branch of the Great Indian Peninsula Railway from Bhosawal in Khandeish, to Nagpur in the Central Provinces, became part of a trunk line not less important than any which preceded it, by the sanction of its extension, on the broad gauge, to join the East Indian Railway near Calcutta.

My rapid sketch of the existing trunk lines of India is now ended, but I must not pass on to their development without pointing out that in one particular, and I think in one only, the trunk line system is still incomplete. The Eastern Bengal Railway was initiated with the view of serving in due time the whole territories to the eastward, and we learn from Lord Lawrence's Minute of 9th January, 1869, that he contemplated its extension to Mymensing, to Chittagong, to Sylhet, and to what is now termed Upper Assam. Mymensing, indeed, can now be reached by what is, and must be, a mere local line, but the great rivers have frustrated the original scheme of carrying the



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Eastern Bengal Railway through from Calcutta to Dacca. Thus, the Bengal territory to the eastward, and the entire province of Assam, are still entirely destitute of railway connection with the rest of India or their own seaport of Chittagong. The districts of Bengal, Sylhet, and Kachar now served by the port of Chittagong are some 19,000 square miles in area, with twice the population of Canada. Some of these districts contain a population averaging from 450 to 750 souls per square mile, others comprise vast tracts of highly fertile alluvial soil absolutely unappropriated, and only awaiting population and means of access to turn out wheat, rice, cotton, oilseeds, tea, and other valuable products. Of tea gardens there are already, in this tract and Upper Assam, nearly 900, worked by some 300,000 coolies, while, finally, excellent coal, petroleum, and other minerals only need a railway in order to create a new industry on a large scale. Chittagong is the natural outlet of these vast resources; and although devoid of either rail or road to the interior, its trade has grown from some 55 lakhs to 320 lakhs in the last twelve years, and all efforts to force the traffic to Calcutta are evidently destined to be futile. In past years there have been difficulties, chiefly financial, which have stood in the way, but now that the pressure of famine and military protection on the one hand, and of the Burma annexation and its consequences on the other, have been greatly relieved, the time has surely arrived when the claims of Eastern Bengal and Assam for the filling up of this vast *lacuna* in our trunk system should obtain precedence over all other schemes of railway extension.

I have already mentioned that Lord Dalhousie, in selecting trunk railways, paid great heed to their suitability to become main channels for the reception of such subordinate lines as might be necessary for special public purposes, or for access to particular districts. To carry you in detail through all the developments of the trunk lines which have been completed or are in progress or contemplation up to the present time, would be of very questionable utility to you, and would unquestionably be tedious, so I shall not attempt it. The map on the wall contains them all, distinguished by narrow lines from the trunk lines, which are shown by broad ones. I shall presently notice those lines which are mainly due to the pressing need for the two special purposes of famine protection and military defence, but will first mention very briefly a few of the chief subsidiary railways whose *raison d'être* was the giving access to particular districts, with the general view of promoting commerce and the public convenience. First among these in importance stands the Oudh and Rohilkund Railway, begun in 1864, opened from Lucknow to Cawnpore in 1866, and Benares in 1874, but not completed according to the full original design, by the extension to Saharanpur and the Ganges bridge at Benares, until the years 1886 and 1887. Next may be placed the South Indian Railway, which started in an elementary form in 1858, but did not until 1874 take its position as a complete system serving all the chief towns of the Carnatic. In 1871 were begun the railway from Agra and Delhi to Ajmere, and also that from the Great Indian Peninsula at Khandwa, *viâ* Indore and Neemuch, to meet this Ajmere line, which Sir John Lawrence, in a minute dated 9th January, 1869, had designed to be "the main line of communication between Upper India and Bombay." This attempt to establish as a trunk line a route by which two ghats must be surmounted, and an additional 137 miles traversed, soon broke down by its own obvious demerits, even though the expectation of a cross-connection between Baroda and Neemuch was held out. The junction of Ahmedabad and Ajmere was, therefore, eventually conceded, thus virtually establishing Lord Dalhousie's original trunk route between Bombay and Upper India, and leaving the Ajmere-Khandwa railway as a local connection of general utility, in which light I now present it. The Northern Bengal Railway, greater in importance than in extent, and opened in 1878, I should not, perhaps, omit to mention. But before leaving this main head of my subject, I must invite your special attention to a highly satisfactory feature in our Indian railway extension, namely, the great readiness in promoting it shown by the native States. I will not pretend to award a palm of precedence to any one of these in the race of enlightenment in which so many have taken and are taking part, as their opportunities arise or their finances permit. First, in point of time, probably stood the Guicowar's little branch from the Bombay-Baroda Railway. This example was, later on, followed by Bhownuggur and other chieftains of Kattiawar, who are supplying quite a complete system for their province; by the Guicowar State itself in recent useful extensions; and by Jodhpur and other principalities in Rajputana. First in magnitude, again, we have the Nizam's State Railway, originally running from his capital to the Great Indian Peninsula line at Wadi, then extended eastward to Bezwara on the Krishna river, hereafter to be connected with the Central Provinces, and all due to the statesmanlike foresight of His Highness's great Minister, the first Sir Salar Jung. Then we have Holkar's connection of Indore with Khandwa, Sindia's subvention of the Gwalior-Agra and the Neemuch sections, the Bhopal Begum's railway from their capital to Hoshungabad, and, finally, the Cashmere Maharaja's line to Jummu, with the contemplated developments to Srinagar itself. All these are the more satisfactory, in that they have been achieved (except in one or two instances only) with capital supplied by India herself. Oodeypoor, Jeypoor, and Travancore have long had useful railways in view, which we may hope will soon be taken in hand.

My notice of what I termed the era of trunk lines, including their chief developments for general purposes, up to the present time, is now complete, and I would invite your attention to the era of famine protection. India, although blessed with a soil of apparently inexhaustible fertility, and a climate normally favourable for rearing a great variety of the choicest products of the earth, is nevertheless subject, on occasions (the recurrence of which has not yet been proved to be regulated by any intelligible law), to famines, which are always productive of vast misery and mortality, and not unfrequently subject to more than decimation the teeming population of even the richest tracts. A cursory glance at the great map on the wall will show that the area more or less liable to famine, which is indicated by the paler Indian-red shade, amounts to nearly one-half of the whole surface of India, and that the parts which have suffered most often, or most severely, as marked in deeper red, are no inconsiderable proportion. The famine railways are shown in vermilion. Those who are tempted to a closer study will find on the side wall a smaller but more elaborate map, in which the famines of different periods are indicated by lines of various colours, and the frequency with which particular districts have suffered may be inferred from the number of such lines intersecting one another. Two other maps, one showing the rainfall, and the other the density of the population, will suggest various remarkable deductions.

As to the nature and extent of these famines I may mention a few facts, mostly derived from the Report of the Famine Commission of 1880, and corroborated by my own knowledge of the whole subject, acquired when holding the post of Famine Secretary to the Government of India during the Madras and Bombay famine of 1876-7. In the 109 years between 1769 and 1878 there occurred twenty-one famines or scarcities extending over twenty-four different years. Four of these occurred in Bengal, nine in the North-West Provinces, two in the Punjab, eight in Rajputana and Central India, nineteen in Bombay, and eight in Madras.. The total mortality they occasioned it is quite impossible to estimate. The North-West Provinces and Rajputana are believed to have lost 1,000,000 in 1837, and perhaps double that number in 1869; the Orissa famine of 1866 is reported to have carried off one-third of the population, or 1,000,000 persons; while some 4,000,000 are held to have perished in Madras, Mysore, and Bombay in 1876-78, Mysore alone losing one-fifth of its inhabitants. Of the extent and cost of relief in earlier famines the records are very imperfect, and the duties of the State in this respect were only gradually recognised. But in the Bengal famine of 1874 about £6,500,000 sterling were expended, and in the Madras-Mysore-Bombay famine of 1876-8, the direct State outlay and remissions of revenue came to fully £11,000,000. These figures, however, do but imperfectly indicate the loss to the people, whose savings of years were depleted, whose cattle died in enormous numbers, whose enfeebled condition rendered them an easy prey to a whole army of fatal diseases, even after actual famine had ceased, and among whom the normal birth-rate was not recovered for some years.

However, interesting and instructive as the history of famines may be, I must not linger over it, but come to closer quarters with my present subject, to which it is only germane and introductory. I have said that the obligations of the State, in respect of famine relief, were only gradually realised and recognised. The famine of 1861, in Upper India, and Colonel Baird Smith's report on it, led the way; the catastrophe of Orissa, in 1866, made a deep impression in all quarters; and the famines of 1874 and 1876-8 enabled a definite course of action to be permanently laid down upon sound principles and a vast experience. With the actual relief of famine have here nothing to do, but the acknowledged duty of its prevention has had a most important influence upon the location and the extension of railways. Among measures preventive of famine, those irrigation works which are independent of local rainfall properly hold the first place, since they have a powerful direct effect in all tracts where they can operate permanently, as well as a certain indirect value commensurate with the surplus produce which they may create and keep available for transfer to other localities suffering from drought. In the earlier years of famine protective effort, therefore, a large share of the funds available for public works was very properly bestowed on them. Turning to railways, when the approaching completion of the original great trunk lines, entrusted to guaranteed companies, led to a review of the whole question of railway extension by Lord Lawrence in his minute of 9th of January, 1869, and when the construction of railways by the State was shortly afterwards commenced, the provision of the main lines of communication still wanting for general purposes, rather than the protection of famine-stricken tracts, was the object in view. At the same time, some of the railways undertaken, such as those across Rajputana, were distinctly valuable for protective purposes. The line from Durbhanga to the Ganges, laid with unprecedented rapidity during the Bengal Famine of 1874, was the first owing its origin solely to protective needs. It was followed by the Dhond-Munmar connection of the two arms of the Great Indian Peninsula Railway, started at the outbreak of famine in Bombay in 1876, with the double object of providing famine relief labour and of avoiding the descent and ascent of the Western Ghats by food grains passing from northern to southern India. In the following year earthworks for famine relief were begun between Bellary and Hooblee, which were the germ of the present Southern Mahratta system. The result of the great famine of 1876-78 was to establish the paramount importance of railways for relief purposes. A speech made to the Legislative Council of the Governor-General by Lord Lytton on 5th January, 1878, contains the following remarks:—

> "It is an unquestionable fact that the railways, and the railways alone, were the salvation of the situation in North Bihar during the famine of 1874, and that they have again been the salvation of the situation in Madras during the famine of the present year. The sea, no doubt, would have thrown rice into the town of Madras; but with the cattle dying of drought, it would have been impossible to move the grain up country; nor if every possible mile of navigable canal had been completed throughout the Madras Presidency, would it have greatly helped us to throw grain into those very districts where the famine has been at its worst; for the broken upland country of Bellary and Kurnool, and the Mysore plateau, are physically impracticable for big canals; and had there been no railway within reach of these districts, the people, where they have now died by hundreds, must have assuredly succumbed by thousands."

A network of subsidiary local lines, to stimulate exchange of commodities and hurry food supplies to any point when the first warnings of serious drought and scarcity appeared, was therefore contemplated at this period, but, unfortunately, the Afghan war soon afterwards turned all available financial resources into other channels. The Parliamentary Committee on Indian Public Works of 1879 next dealt with the subject. While admitting the value of irrigation canals where physical conditions were specially favourable to them, they pointed out that such conditions were absent throughout large portions of India, including very many of those most subject to famine, and they held the prosecution of railways and other communications to be the most likely means of preventing or mitigating famine.

The Famine Commission of 1880 took a view of the paramount importance of railways for famine relief similar to those of Lord Lytton's Government and the Parliamentary Committee, and practically put an end to all further controversy on the subject. They roughly estimated 5,000 miles of railway to be required to meet the "probable present needs of the more accessible tracts for which protection is pressingly required," but abstained from specific recommendations, and only indicated certain tracts as requiring early attention.

I have already alluded to the Afghan war as interfering with the prosecution of famine railway projects. The consideration of the subject continued, however, and the year 1880, when Lord Ripon—who has been so good as to preside here to-day—assumed the Viceroyalty, was the commencement of a decade which may be comprehensively described as one of unprecedented railway progress. Considering the objects to which that progress has been directed, this decade may be said to comprise the remainder of the era of famine protection which we are now reviewing, and also the era of military defence, the latter having supervened in the course of the year

1884. From an administrative point of view, it is marked by a return from the policy of employing State agency exclusively in railway construction to that of enlisting largely the services of Companies. Financially, the period has been one of considerably increased railway outlay in one form or another, but that outlay has latterly been to a great extent directed to objects other than the internal development of India; at the same time, it has been notable for repeated and searching discussions of the fundamental principles of railway extension, such as gauge, agency, State aid, and the relative claims of famine, commercial and military projects; while, finally, an ever-falling exchange interposed obstacles to the regular supply of funds which were most embarrassing to the Public Works Department, and the reverse of conducive to economy. Upon some of these points I propose to touch briefly before I conclude to-night, but to deal satisfactorily with them all would need far more time than we have at our disposal.

The progress in railway construction since the effective commencement in 1852-53 may be readily seen from the following statement:—

	MILEAGE IN DECEMBER.											
	1868.		1878.		1881.		1884.		1887.		1889.	
AGENCY.	Open.	Under construction.	Open.	Under construction.	Open.	Under construction.	Open.	Under construction.	Open.	Under construction.	Open.	Under construction
State Railways:—												
Under Director-General of Railways	...	...	1,457¾	661¼	2,123½	177¼	2,696½	1,285¾	2,393¾	446½	3,478	237
Worked by Companies	...	...			1,747¼	457¼	1,966	513½	4,440¼	1,358¼	6 100	644
Under Local Governments, &c.	...	...			46½	...	46½	...	445	2¼	...	...
State Provincial	...	...	558¼	287¾	873¾	618½	1,365¾	527¼	1,580½	166	1,627	91
Guaranteed Companies	4,017	1,635	6,044	4½	4,589¾	142¼	4,523½	108¾	3,898¾	11½	3,241	...
Assisted Companies............................	...	...	...	...	56½	332	388	520	643	19	594	162
Native States	...	...	155	35¼	445¾	89¾	643¾	331	755¼	236½	1,201	307
Total	4 017	1,635	8,215	988¾	9,883	1,817¼	11,629½	3,286¼	14,156½	2,231	16,241	1,441
	5,652		9,204		11,700		14,916		16,387		17,682	

The changes from one head to another at the various periods are very suggestive, and will presently be alluded to more specifically.

Some idea of the objects to which this progress has been directed will be obtained from the subjoined Table:—

	MILEAGE IN DECEMBER.									
	1881.		1882.		1884.		1887.		1889.	
	Open.	Under construction.	Open.	Under construction.	Open.	Under construction.	Open.	Under construction.	Open.	Under construction.
INTERNAL RAILWAYS. "Productive," *i.e.*, for commercial purposes only, and expected to pay 4 per cent. within five years	6,513½	816¼	6,605¼	817½	7,132	476½	7,570½	122¾	7,693	487
Protective	145¾	...	145¾	...	145¾	361	317¾	188¾	506	393
Protective and Productive	1,552½	864¼	1,662	1,435	2,501¼	2,317¾	3,809½	1661¾	5,360	327
Military and Productive	1,671¼	136¾	1,731½	103½	1,850½	...	1,843¼	...	1,843	...
Total	9,883	1,817¼	10,144½	2,356	11,629½	3,155¼	13,541	1,973¼	15,402	1,207
FRONTIER MILITAEY RAILWAYS	...		...	...	..	131	615½	258¾	839	235
Grand total	9,883	1,817¼	10,144½	2,356	11,629½	3,286¼	14,156½	2,233	16,241	1,442
	11,700		12,500		14,916		16,389		17,683	

The years 1880-81-82 were remarkable, on the one hand, for the commencement of several important railways both by State and private agency; and on the other, for the complete examination by the Government of India of its own position and resources, and of the needs of the country. Some of the railways then started, or already in hand from previous years, had famine protection, others had commercial and public convenience, and others military defence for their chief object. It was not until January, 1883, when I had held for some six months the post of Member of the Governor-General's Council in charge of Public Works, that the Government were able to see their way clearly to a definite policy to be pursued systematically for a series of years. Being deeply impressed with the urgency of protection against famine, we came to the conclusion that while lines actually in hand, of whatever class, must, of course, be completed, the public resources must otherwise be exclusively devoted, for the next five or six years, to such new projects as were of a protective character. All railway projects were therefore classified into two schedules, A and B. Schedule A, of indispensable railways, comprised (with a few later additions) 4,580 miles of railway, of which 1,026 belonged to projects or systems already open or commenced, and 3,554 miles were entirely new. Nearly the whole of this mileage was of the "protective" class, but only about one-third of it was considered to be unlikely also to serve commercial and general purposes sufficiently to ensure a fair interest on the capital outlay. Schedule B was composed of about 3,500 miles of railways which, though mostly desirable in themselves, were not indipensable for famine, or other urgent needs, and must therefore, however much their exclusion might be regretted, stand aside for a time, on financial grounds, and be left to private enterprise, unaided except by the free grant of land.

What this scheme of famine protection, together with some few railways begun in anticipation of it, really embraced, I will now endeavour to set before you as clearly as time and circumstances will allow. The scheme has for its nucleus a certain tract in the centre of India, which was thus graphically described by my friend Sir William W. Hunter in his evidence before the Parliamentary Committee on Indian Railways in 1884:—

"The Chattisgurh country is a large area of about 24,000 square miles, with a small population of 128 per square mile, an abundant and uniform rainfall, and a fertile soil. This country is known to native merchants as the land of threshing-floors, on account of the fertility of its fields. The officer who made the land settlement said that the people fed all passers by. The tract owes its fertility partly to a rich soil, but chiefly to the fact that it has the most uniform and, on the whole, the most trustworthy rainfall in India. It forms a sort of meteorological horseshoe, a great amphitheatre up which the monsoon is driven, and at the northern and western extremities of which the monsoon is arrested by the hills, so that it drops a uniform and steady supply of water every year. Several of the great rivers issue from those hills. The Sone river goes from the north and joins the Ganges; the Mahanuddy river strikes to the south-east and passes through Orissa into the Bay of Bengal; the Nerbudda flows west into the Arabian Sea; the Godavery rises a little to the southward and falls into the Bay of Bengal. . . . . . . The Chattisgurh country raises annually 241,000 tons of grain more than the people consume. We also find that the prices are exceedingly low."

From this nucleus, or granary, the Government of India considered it to be essential to conduct lines of railway establishing communication with all the five provinces of India which have suffered most from famine. First of these lines in magnitude and importance is the Bengal-Nagpur. To begin with, it connects the granary with Northern Bengal and Behar. There, its action is supported by the Assam - Behar railway, traversing both districts, from Tirhoot to the Brahma-putra, and by the Bengal and North - Western Railway, running from Patna through the trans-Gogra country to the north-west. Succour will thus be carried, when needful, to the tracts which were famine stricken in 1866 and 1874. Next, it throws off a branch to Cuttack, which should render impossible, in Orissa, another disaster such as that of 1869. Again, from Bilaspur, this same Bengal-Nagpur throws off another branch northward, to join the East Indian at Kutni, which will convey food grain on to that line, and over it on to the Indian Midland, a railway specially designed to traverse in more than one direction, the whole of Bundelkhund and the native states south of Agra, which have suffered from five famines since 1837. Beyond this Indian Midland also, and connected with it, directly or indirectly, lie the specially protective Cawnpore-Furrakabad, the Lucknow-Sitapur-Bareilly, and the Rewari-Ferozepore, which, with the other railways in those parts, will distribute the grain derived from Chattisgurh throughout Rohilkhund, North Rajputana, and the Southern Punjab. Fourthly, this Chattisgurh granary is placed in touch, *viâ* the great Indian Peninsula and its Dhond-Munmar cross-line, with Western and Southern India, and will be so even more directly as soon as the Nizam's State Railway is extended northwards to join the Bengal-Nagpur. For Western and Southern India a local system of protective lines has also been provided. The Southern Mahratta Railway has sections running through both the East and the West Deccan, as also down the Southern Mahratta country across Mysore, while crosswise it traverses the entire peninsula, and will soon have a second link with Bangalore from Dharmaveram. It is thus able, either directly or through its connections, to distribute grain, whether sea-borne from the harbour of Marmagao, or produced in the irrigated delta of the Kistna, or supplied from Upper India, in relief of all the districts of the peninsula which have ever been famine stricken. Of its connections, the Madras and South Indian need no remark; but I may invite notice of the new line from Guntakul to Villupuram, with its branch to Nellore, and the connection with Bangalore just mentioned, which can thus draw food not only from the north, but from the deltas irrigated out of the Pennair, Caveri, and Coleroon rivers. Gujerat and Rajputana are now fairly protected by the numerous branches made and to be made by Native States. Lest any one should suppose that no aid can come from the north, or that the value of Chattisgurh to Western or Southern India is visionary, I may mention that during the great famine of 1876-78 grain went freely to the latter, even from the Punjab north of Delhi. Lest, again, any one should be disposed to think that the supply of famine lines has been overdone, I would remind you, not only that when we are dealing with a territory so vast as India large areas look small on maps, but also that physical difficulties are often an absolute bar to communication between places apparently close to each other. This Guntakul-Villupuram line, for instance, runs in its upper portion through a tract which suffered most severely in the last famine. At the time I could not understand the cause of this, in view of the proximity of the Madras Railway, but on afterwards visiting the locality I recognised it in a range of high hills between the two, across which the few and emaciated cattle surviving were utterly unable to transport a load.

Such, in brief, was the famine railway scheme as matured in 1882-83, though begun before that date in some of its detached portions. Upon the innumerable obstacles to its completion I must not dwell. Not only had the necessity for, and protective value of, every individual railway to be established, but it was even in question whether a railway was "protective" if it did not actually traverse a famine-stricken tract, but only conveyed food to such a tract from other food-producing localities. The economy of a protective railway in saving future outlay, even though it would not ordinarily earn a high dividend; the objections to deferring famine lines till they could be entirely built out of surplus revenue; and the value of time when famines were periodical—all these points, and many more, had to be debated. Even when projects were in full course of construction, they had in some cases to be suspended at a heavy loss because temporary financial pressure had occurred. And above all supervened the new urgent need for military railways. Lord Ripon's Government in 1884 found themselves confronted by two evils—famine and complications on the north-western frontier. Considering that the accepted famine cycle was nearing its close, most persons might well think the former the more likely to supervene; but it could not be forgotten that the best way of deferring the latter was to make timely preparation against them. It appeared that the protection from both ought certainly to be provided concurrently, and to the full extent necessary in the case of each. However, funds were limited, and the frontier railways obtained much precedence over the famine lines, which have been greatly delayed in consequence.

Ere Lord Ripon retired from the viceroyalty, not only the Indian Midland but the Bengal-Nagpur project, which is the backbone of the whole, had actually been commenced, and yet both were afterwards stopped, and had to pass a second time through the crucible of destructive criticism. I am glad to think, however, that they came out unscathed, and that before I left India above two years ago the completion of nearly the whole famine programme was practically assured. Since then it has proceeded in ordinary course, and I understand that by the end of the present year, although the junction of the Assam-Behar with the Brahmaputra river at Dhubri, and of the Nizam's and Bengal-Nagpur railways are still wanting, only one project of really primary importance will remain untouched. I allude to the branch already noticed, from the Bengal-Nagpur Railway to Cuttack, termed the Panchpara-Puri. I feel that nothing I might say could exaggerate the significance of this omission. A million of human beings perished in Orissa in 1869, and a million and a half sterling was spent in mostly futile measures of relief. Since then, nothing has been done to improve the communications, except the far from satisfactory East Coast Canal. This railway would cost under two millions, and would convey food grain at will from Chattisgurh on the one hand, or Bengal on the other. Orissa is now virtually unprotected. Let the Government look to it—let them, I say, look to it ere trouble come.

The era of military defence supervened upon that of famine protection much in the same sort of way that the latter advanced upon and overlaid the era of trunk lines, that is to say, at first gradually and imperceptibly, but afterwards with peremptory and irresistible urgency. I will now treat of it, premising that the military railways are coloured yellow in the great map on the wall. The value of railways for military purposes had, of course, been recognised from the first. Lord Dalhousie had enlarged upon the greater military strength, combined with reduced numbers, cost, and burden in our army which they would insure. In subsequent discussions, and notably in those connected with the gauge question, the point was not overlooked, A start was also made towards completing the trunk line from Lahore to Peshawar, and linking together the Punjab and Sind. But, still, it was not until trouble upon the north-western frontier was foreshadowed, that the importance of rapidly completing these connections received practical recognition. In fact, when the Afghan war began, in November, 1878, we were caught with the "Punjab Northern" line from Lahore to Peshawar only just opened to Jhelum (103 miles out of a total of 279), and the Multan-Kotri link in a very unfinished condition, though available for traffic, except at the Indus crossing. Both did excellent service up to their means during the emergency, but the former could not be made available as far as Attock till January, 1881, or opened for traffic throughout until June, 1883, while the latter was hampered by a ferry-crossing of the Indus until last year, when was opened the great Sukkur Bridge, the site of which I was able at last to settle in 1883.

Although these two lines are in reality only sections of the two great trunk railways opening up the Punjab and Sind, I notice them again on account of their especial military value, and will now turn to their strictly military developments. The first two of the latter owe their origin to the Afghan war. The Ruk-Sibi line (133 miles) was made across the desert between October 5th, 1879, and January 16th, 1880, and subsequently extended to Pirchokee, in order to aid our armies on their march up the Bolan Pass. The Rawal Pindi-Kushalgurh line (67 miles) was sanctioned about the same time, with the view of supporting our troops in the Koorum valley, but not opened until April, 1881. The extension of the Ruk-Sibi railway by the Harnai route to Pishin and Kandahar (278 miles) was actually commenced in 1880, but the cessation of the war led to the abandonment of the works in the course of the year.

From this time until the close of 1883, the question of frontier military railways may be said to have slept, but those who could read the signs of the times then, saw the necessity of extensive preparations for future emergencies without delay. In November, 1882, I personally examined the lower part of the Harnai route. A year later, the work of overcoming the formidable obstacles to a road or railway presented by the gorges just beyond Sibi, together with the careful survey of the Harnai route to Quetta, were undertaken, under General James Browne, C.B., C.S.I., as engineer-in-chief, and in the spring of 1884 the construction of the railway to Quetta, with a branch into the Pishin valley, was sanctioned. But this measure was not deemed sufficient. In the autumn the Government of India considered the whole question of frontier defence, and obtained the approval of the Secretary of State for (1) a railway, termed the Sind-Sagar, which should run from Lala Musa to the Indus opposite Dera Ismail Khan, thence down its west bank to opposite Dera Ghazi Khan, and back eastwards across the Chenab to Multan, with efficient ferries for those three great military stations; (2) a bridge across the Sutlej at Ferozepur, so as to render the great arsenal there more readily available; and (3) two great military roads, one of 195 miles, from Dera Ismail Khan by Bunnoo and Kohat to the railway terminus at Khushalgurh, and the other of 250 miles, from Dera Ghazi Khan to the Pishin valley. Various other measures which have since been adopted, such as the tunnelling of the Amran, and the provision of a reserve of railway material for an extension to Kandahar when required, were at the time brought forward, but deferred pending the meeting of primary needs.

I may here be pardoned, I hope, for making the digression of remarking that these important measures, constituting the backbone of the defences of our north-western frontier, were matured and begun before the termination of Lord Ripon's viceroyalty, when the Commander-in-Chief was General Sir Donald Stewart, and the Military Member of Council, the late General Wilson.

Thus far we have the frontier railway arrangements of 1884. In March and April, 1885, however, the need for military facilities of communication suddenly reached a more acute stage, owing to the attack on Afghan troops by Russia at Panjdeh, and the consequent preparation of two Corps of the Indian Army to advance to Pishin and Kandahar. In order to relieve transport, especially in the Lower Bolan, the immediate commencement was ordered of a temporary extension of the railway from Pirchokee, up the Bolan Pass, to Mach, with special steep incline up the Dozan Gorge, to the plateau at Darwaza, and a permanent branch thence to the Sind-Pishin Railway at Quetta. At the same time, the extension of that railway to the foot of the Amran Range, and the provision of 150 miles of reserve permanent way for a continuation thence to Kandahar in case of need, were decided upon. Shortly afterwards, the Secretary of State approved of the completion of the railway through or over the Range by the most suitable route to our actual frontier, the conversion of the Bolan Railway into a permanent alternative of the Sind-Pishin, the creation of a branch of the Sind-Sagar Railway to Mianwali (recently extended to Mari on the Indus), with a view to future communication with Bunnoo, and the improvement of certain steep gradients on the Lahore-Peshawar Railway, as also the connection of Bhawalpoor with Ajmere. Later on, in 1887, the same authority approved a bridge, instead of the ferry, for the crossing of the Sind-Sagar Railway over the Chenab near Multan, and the piercing of the Amran Range by a tunnel two and a half miles long at the Khojak Pass. Most of these undertakings had been carried out, and the last two were started, before I left India. The only ones which are still under consideration, but no doubt will receive effect in due course, are the extension of the Sind-Sagar line from Mari to Bunnoo on the one side, and to join the Khushalgur branch on the other, as also the connection of Bhawalpoor with Ajmere.

I will now trespass on your patience with a brief account of the construction of some of these great works, followed by an exposition of their design and value for defence as a connected whole.

First must claim attention the Sind-Pishin Railway, which was a work of the most formidable character. Not merely were there two defiles, necessitating numerous large bridges, together with tunnels and deep cuttings in material so rotten as to involve constant danger to life, and a singular gorge, called the "Chupper Rift," overcome by several tunnels in the cliffs, and a bridge at a very high level, but the climate was of the most inclement nature, below so hot in summer, and above so cold in winter (the maximum altitude being 6,200 feet), as to paralyse progress on one portion or the other for months together. Preliminary operations began, as we have seen, in November, 1883, and by July 1st, 1884, work as for the sanctioned railway was in full swing. On the 1st of November, 1886, the rails from below had advanced 98 miles, to the foot of the Chupper Rift. Meanwhile, with the aid of the transport supplied by the Bolan Railway, which had reached Quetta on 10th of August of the same year, rails and bridge girders were supplied to the upper part of the line which descended thence to the Chupper Rift, so that the rails met, and communication between Sibi and Quetta (155 miles), was established, on the 14th of March, 1887. By about the same date the 41 miles on the plateau of Pishin, from Bostan Junction to the foot of the Amran Range, were opened with the exception of one bridge. Even allowing for the fact, recorded by the Director-General of Railways in his annual report, that the aid of the Bolan Railway accelerated the work by a year, and that many details of buildings, linings, &c., were unfinished in March, 1887, so that opening for traffic was deferred till August, the establishment of through communication in a mountainous country in so short a time, notwithstanding all the trials of climate, fever, scurvy, dysentery, and death of engineers and labourers alike, was a triumph of skill, courage, self-sacrifice, and endurance on the part of General Browne and his staff which has few parallels.

On the other hand, the Bolan Railway

afforded to its staff full scope for the display of the same virtues, in surmounting the same class of difficulties, though for a less lengthy period. Work commenced, though with only a portion of the destined staff and coolies, about May 1st, 1885; but on the 18th, Colonel Lindsay, R.E., the engineer-in-chief, had a severe fall from a trolly, which incapacitated him from outdoor work, and by June 9th obliged him to leave for Bombay. Meanwhile severe cholera and other epidemics had broken out, which, with the normal intense heat, so disabled and demoralised the whole, that on the arrival, on June 24th, of Mr. F. L. O'Callaghan, C.I.E., the new engineer-in-chief—who was the constructor of the great Attock Bridge, and had laid out and begun the Sind-Sagar Railway—he found only four engineers and 200 men fit for work. On July 20th active operations were resumed, in the face of climate and disease, and by October 30th an ordinary train conveyed the Commander-in-Chief (Sir Donald Stewart) and myself to Mach, a length of 42 miles, and at an altitude of about 3,000 feet. Construction was pushed on during the winter, notwithstanding the severe cold, but owing to delay in supplying piping and other materials from England, the rails did not reach the plateau at Darwaza, 5,400 feet high, till April 1st, 1886, and Quetta till July 27th. Other arrangements were so advanced, however, that the opening for public traffic was effected a fortnight later. The transport of materials for the upper portions of the Sind-Pishin Railway and of the Kandahar Reserve to Hirok, within 10 miles of the plateau, had meanwhile begun on November 20th, so that their subsequent transmission onward was greatly accelerated. The cost of the Bolan Railway to the plateau, 57 miles, was 54 lakhs as first completed, with the upper 10 miles of steep incline on the metre gauge, worked by Fairlie engines, but since it has been converted to broad gauge throughout, the total is 69 lakhs, or Rs. 1,21,000 per mile, which is a very low figure for a mountain line, constructed against time, and under extraordinary difficulties from both climate and epidemics. Being partly laid in the bed of the river, it is exposed to injury from floods, and has suffered on more than one occasion. But experience has shown that the damage they do is not very serious, and can be rapidly repaired. The total cost of special repairs in the four years since opening have not amounted to one-half the similar outlay of last year alone on the Harnai, which was at the outset supposed to have a comparative immunity in this respect. Temporarily it, to a great extent, repaid its cost in conveying 70,000 tons of Sind-Pishin and Reserve material to the plateau, and accelerating by a year the opening of the Harnai route; permanently, it affords an alternative line far more valuable than doubling that route would have been. From every point of view, therefore, the Bolan line may be pronounced a conspicuous success. The services of Mr. O'Callaghan and his staff were publicly recognised and rewarded by the Government, as were those of General (now Sir James) Browne and his coadjutors.

But I must not dwell on these constructive particulars further than to mention that the whole of the military works sanctioned in 1884, and the Bolan Railway in addition, were completed within the four years originally assigned to them. Moreover, the Chenab bridge was designed and completed within two years of sanction, and, above all, the Khojak tunnel, of the possibility of which Mr. O'Callaghan, C.S.I., C.I.E., was the discoverer, and to the designing and construction of which he passed after the opening of the Bolan, will, I understand, be ready within the time—two years and a-half—he originally named. The Amran extension is 39 miles long, and the tunnel is 2 miles and 710 yards long, at a height of 6,392 feet. A special feature of the work is the temporary line carried over the top of the mountain, 7,260 feet high, with inclines of 1 to 2½. It was made in ten months, and has been constantly employed in conveying material, supplies, and the Kandahar Reserve to the western side. These inclines will be understood from the two views projected on the screen. The second shows the western incline and the temporary railway, with, in the foreground, the shaft to the tunnel leadings, 281 feet below. The whole country, you will observe, is covered with snow.

The opposite end of the empire, Burma, has since the conquest of its upper province, developed a frontier railway system of its own. The two lines from Rangoon to Prome and Tonghoo have already been alluded to. The eastern was chosen for the continuation to Mandalay, partly in order to leave the river as a second independent channel of communication, but chiefly because of its military and commercial advantages in bisecting East Burma, and commanding the Shan States. To Mandalay, the 225 miles of new line were achieved by Mr. J. W. Buyers, C.I.E., and his staff, in two years. An extension to the northward, to complete the pacification and development of those districts, is now in progress.

I have now left myself but little time to fulfil my promise of explaining the design and value of the north-western frontier defence scheme, as a whole. A brief study of the map before you will suffice. In the first place, the Sind-Sagar Railway now gives us, through Jhelum, and eventually, when the Mari-Khushalgur extension is made, will give us, through Rawal Pindi, unbroken railway communication along the line of the Indus (and behind it at the most important part) from our extreme right at Peshawar to our European base at Kurachi — a line which may be stated, roughly, at 900 miles. Next, we have three projections from this line to our actual border towards Afghanistan. From Peshawar we have ready for use a 12-mile unopened continuation of the railway to Jamrud, and a good road up the Khyber Pass to the frontier post of Landi Kotal, on the way to Jelalabad and Kabul. More direct communication by the Cabul river has been long under consideration. Again, from the rail-head at Khushalghur, one of the first-class military roads of 1884 runs through Kohat to our great station of Bunnoo, which commands access to Ghazni, and thence back to the great station of Dera Ismail, which touches the Sind-Sagar Railway. The railway extension to Bunnoo from Mari, and the connection of Mari and the Khushalgurh branch, will probably not be long deferred. Thirdly, the Sind-Pishin Railway is projected for some 300 miles, as the crow flies, from Ruk, in Sind, to our actual frontier beyond the Amran range, the famous "scientific frontier" of which we once heard so much. This railway is practically level to the foot of the Beluchistan mountains; it then suddenly rises, over crests of 5,400 and 6,200 feet high, into the Quetta and Pishin valleys, and after traversing these by easy gradients, it pierces the Amran range, and emerges into comparatively level country extending to Kandahar, the distance of which from its terminus is about 80 miles. It will be observed that the Sind-Pishin Railway is liable to have thrown upon it, in time of military emergency, the whole traffic of two lines—that is to say, the resources of India from the Lahore side, and the resources of England from Karachi; in other words, it may have to do the work of a double line. To meet this, the single and comparatively level parts in the Sind plain and the upper valleys have been provided with extra crossing-stations, sidings, &c., such as are usual for meeting extraordinary strains. The two mountain parts, where their steep gradients reduce greatly the train load elsewhere practicable, actually possess a double line. The passage of the Khojak is laid with two lines of rails throughout; the Bolan and Harnai alternatives are better than any double line could be, for they may be used as ascending and descending routes, having independent staff, and in the event of accident to the works of either, the communication by the other would be unimpaired. The capabilities of this line are completed by the storage at its terminus of all the necessary material for a prompt extension to Kandahar. Finally, its own resources in this quarter are materially supplemented by the second military road of 1884, from Dera Ghazi Khan to Pishin, with branch to Harnai on the railway, by which supplies or reinforcements could be thrown in from the independent base of Dera Ghazi Khan, or troops could be rapidly transferred from Pishin, *viâ* Harnai, to the cantonment of Loralai, in the centre of the road, to meet any emergency in that quarter. To the entire frontier system, a connection of Bhawalpore and Ajmere, giving in its very centre an extra source of supply from the heart of India, would be a most valuable adjunct.

As regards all the lines to which I have been referring, I should mention that the opportunity of the termination of the Sind, Punjab, and Delhi Railway Company's contract in 1885 was used to purchase back the undertaking, which consisted of two parts of main trunk lines, inconveniently alternating with two other parts of the same belonging to the State. The whole was then consolidated into one system, now comprising some 2,500 miles, freed from divided control, improved locally in traffic facilities, too detailed for me to specify, and officered and organised on a semi-military basis, with special view to the great purpose it may at any time be called on to serve, unbroken throughout, and on the broad gauge, so as to have an unlimited reserve of stock in all the similar railways of India. Thus, it can be wielded by one head, and constitutes, perhaps, the most powerful weapon we possess for defence against foreign aggression. I sincerely trust that no visionary commercial advantages, and no lust of political predominance in distant countries, will tempt us to advance beyond our existing and recognised sphere of influence, or to make paths, for our foes perchance, as well as ourselves, across deserts and mountains which are now to us an effective barrier of defence.

My explanations of the *raison d'être* of the railways, in respect of their alignment, are now concluded, but, before passing to the second and totally different branch of my subject, which relates to places of architectural interest on the new railways, I must trouble you with a sketch of the *raison d'être* in the two important other particulars of gauge and administration, and some sort of forecast of railway extension in the future.

Commencing with gauge, and referring you to the map projected on the screen before you, it will be seen that we have (with some trifling exceptions) only two gauges, the broad, of 5 ft. 6 in., and the metre, of 3 ft. 3 in., there indicated by black and red lines. The former is adopted on 10,728 miles out of the total 17,683 open and under construction. Lord Dalhousie, in 1850, after very full deliberation, was of opinion that the evidence given before the Gauge Commissioners in 1846, and certain Parliamentary Committees showed that the 4 ft. 8½ in. gauge, which had been originally adapted in England at haphazard, and from the accident of local circumstances, was not the best for general railway purposes, and that something intermediate between it and the Brunel gauge of 7 feet was best suited to the needs of India. His Lordship inclined to 6 feet as the solution, but the Court of Directors preferred 5 feet 6 inches, which eventually was acquiesced in, and adopted for all the great guaranteed railways. The question of using a smaller gauge was first definitely raised in 1861-62 on certain proposals for branch railways in Northern India, and thereupon commenced a controversy which raged between the highest authorities for many years. Each view was supported at different periods by arguments more or less different, and each had its vicissitudes of predominance and depression. It would be quite impossible for me adequately either to summarise the former or to trace the latter. All that I can venture upon is a mere outline of broad features, governed by a sincere desire not to do injustice to the holders of either view, of which I may offer as a pledge the fact that while I have, during my public works administration, vigorously advocated the broad gauge in some instances, I have in others, either where the metre gauge seemed on the whole suitable, or in deference to accomplished facts, proposed and adopted it of my own motion.

The very heavy cost of the early guaranteed railways, and their prolonged inability to earn the guaranteed interest, were at the bottom of the desire for a cheaper style of line, whether by reduction in width of gauge or by using lighter rails and engines, with a reduced speed, upon the standard gauge. At the outset no more was proposed than that the new system should be applied to "feeders to the main system, but not essential parts of it," in cases where the traffic would not warrant the outlay for the full standard, "as a temporary expedient, on the conviction that such lines will be replaced by full-gauge lines of a more substantial character whenever the development of traffic" required it. It was not disputed that "the great primary network" of railways must be on the full "standard or national gauge," and it was urged that there was "no risk" of lines bearing this "temporary and provisional character" growing into a system which would compete with the former. They were to be mere "branch railways, which were never likely to become through routes of communication," used for light local traffic, where a slow speed was sufficient. Language not materially differing from this was used in advocating the system even recently. But when, later on, the idea had taken the form of a 3 ft. 3 in. gauge, instead of a light railway on the standard gauge, and had obtained a certain footing in the country, its advocates, not content with its adoption in isolated or very backward provinces, sought for it a far wider and a permanent field, if, indeed, did not contemplate its gradually ousting the broad gauge in all existing railways. Pessimist views were advanced of the prospects of traffic, the "trunk" character of such lines as those from Lahore to Karachi and Peshawar, and from Bombay to Delhi was ignored, it was contended that the Lahore-Karachi, and the Delhi-Bombay, respectively, would be "a permanent source of taxation to India," and "never pay," and it was thus proposed to establish these latter on the metre-gauge throughout, by the conversion of some 700 miles of open broad gauge. On the other hand, the mercantile community invariably took an enlarged view of traffic prospects, which has been justified by the event. Experts of various classes also maintained that the initial saving in capital by metre gauge was exaggerated by comparisons with the abnormal cost of the old guaranteed railways when construction was in its infancy, that this saving, such as it truly was, was outweighed by the greater cost of working, and vanished as soon as the line had to be strengthened to meet a heavy traffic, and that for real military, famine, or commercial emergencies, a metre gauge was inadequate. Over the two undoubtedly trunk lines which I have named a definite contest lasted for some years. The Punjab-Sind system, after "light broad gauge" had been abandoned for metre, was at length established on the broad gauge, chiefly by the military arguments of Lord Napier and Major (now Sir Frederick) Roberts, but the Delhi-Ahmedabad was left to its fate, and remains, a formidable though not, I may hope, a permanent obstacle to commercial and military efficiency of transit. For some years the metre gauge thus obtained a preference, but no very conspicuous cases of doubt as to its applicability arose until 1883-4, when the proposed Bengal, Nagpur, and Indian Midland trunk lines came in question. The Government of India in the latter year addressed to the Secretary of State a Despatch in which the necessity of the broad gauge for all through trunk lines, and for all short connections between such, was insisted on, while it was admitted that the metre gauge would suffice for very backward, scantily-peopled, or isolated provinces, or for short provincial and local branches into districts where the traffic would obviously not repay construction on the same gauge as the main line. These views were substantially adopted by the Select Committee of the House of Commons of that year, whose report, dated 18th July, 1884, contains the following passage:—

> "With regard to the question of gauge, your committee are of opinion that all the leading trunk lines, with their principal feeders, should be on the broad gauge, the metre gauge being as a rule confined to tracts of country where that system is already in successful operation, and to local lines where the traffic is likely to be so light that cheapness of construction more than counterbalances the undoubted disadvantage of break of gauge."

In consequence of this decision, doubtless, the broad gauge was without difficulty adopted for the Indian Midland Railway in 1885. In the following year, however, the proposal was again made to extend the metre gauge of the Nagpur-Chhatisgurh Railway to the whole Bengal-Nagpur Railway, though it would be one of the most important trunk lines in India. The ultimate decision in 1887 in favour of the broad gauge will prove, it may be hoped, the termination of the prolonged controversy on this subject. To those technically interested in the subject I would commend for perusal the evidence before the Committee, and the correspondence published in 1888 by the Government of India, as No. 238 of their "Selections from the Records."

In conclusion of this subject, I may be allowed to remark that, looking back upon the whole question by the light of experience, bearing in mind the enormous increase of late years in the wheat and other goods and the passenger traffic, the emergencies which at one period laid the whole of Northern and Central India under contribution for food to save the starving South, and at another brought us face to face with the problem of how to place, in the shortest possible time, an army of fully 50,000 men, with their supplies, in the Pishin Valley, and the fact that we have already some 1,080 miles of double broad gauge line, I feel that we may dismiss all regrets that the standard gauge of India is fixed at 5 ft. 6 in. Rather, perhaps, without disputing the sufficiency and appropriateness of the metre gauge to certain specially circumstanced localities, may we wish to see a freer recognition of the value of light lines on the broad gauge, approved by Lord Elgin's Government, but afterwards too entirely discarded, which have an obvious convenience in the case of short local connections, and can be made very readily and cheaply now that our main lines turn out annually some hundreds of miles of broad-gauge rails, which are still not too worn to bear a light traffic.

My next point is the rationale of our Indian railways in respect of their administration, and here again I must refer you to another map projected on the screen, where State railways are red, company's railways black, and State railways, worked by companies, dotted black. Of the total railways open and under construction, 13,627 miles are the property of the State and native States, of which 7,370 miles are worked for them by Companies, and 4,056 miles belong to Companies which work them on their own account.

Our early railways were, I need scarcely repeat, all made by guaranteed companies. This system was preferred by Lord Dalhousie, partly on the *à priori* ground that Government should as far as possible abstain from commercial enterprises, and partly because the existing Public Works staff, though highly trained, was quite insufficient to add railways to the canals, roads, and buildings already on their hands, but Companies were willing to undertake them with experienced engineers from England. To these Companies he was willing to give a guarantee, but guarded by very stringent control. His system was adopted, but not his precautions, with the result that the guaranteed railways had, in 20 years, cost an average of £17,000 per mile, or about double what he contemplated, and on one the amount had reached £23,000. This produced a strong reaction in favour of railway construction exclusively by the State, which was advocated by Lord Lawrence in 1869, and soon formally adopted as an exclusive policy. For ten years it reigned practically unquestioned, except by some remarks of Lord Salisbury's in 1877, in favour of State railways worked by Companies. But when an improvement in the finances led to a desire for railway extension on a large scale, Lord Ripon's Government felt that the exclusive use of State agency involved considerable risk of the growth of costly establishments, as well as large additions to the direct public debt of India. To the latter the Home Government, on the advice of the Parliamentary Committee of 1879, were especially averse. Companies required, no doubt, a small share of profits which would be reaped by the State when using its own agency, but they had the advantage that the capital they borrowed did not appear as State debt, and that their action was free from the costly uncertainty as to provision of funds which accompanies annual Budget grants and living hand to mouth financially. A further difficulty of State agency lay in the restrictions then in force upon using borrowed money for railways which could not confidently be expected to return 4 per cent. soon after their opening. It was held, therefore, that Companies might very properly be used, either almost unaided, or under guarantees limited by various restrictions, for the construction and working of railways which should be either the property of the State, or purchasable at short periods on reasonable terms. In fact, a new policy was started, under the Viceroyalty of Lord Ripon, of employing both State and companies' agency as far as the finances would allow. There appeared to be ample room for both, and nothing to be gained, but much to be lost, by excluding either altogether.

Expectations were at first entertained that railways which offered a fair prospect of becoming remunerative might be constructed by Companies, either without a guarantee, or, at most, under a guarantee limited to the first five or seven years spent in construction and the initiation of a fair traffic. The Bengal Central Railway Company was the first launched on the new system early in 1881, and it obtained from the State only a "limited guarantee." The little Assam Railway Company also belongs to this period. Early in 1882, the Southern Mahratta Company was formed on the novel basis of "construction and working" only, the railway being the property of the State, though worked by the Company, and made with funds supplied by them in return for a guarantee of 4 per cent. for seven years, and 3½ per cent. subsequently, accompanied by a fourth share in net profits. Later on in the year, the Bengal and North-Western Company was brought out to make the line termed "Patna-Bahraich," which was deemed to be so promising that no guarantee was asked, and a share in profits above 6 per cent. was reserved to the Government. Proposals to make the Bengal-Nagpur line on the "limited guarantee" basis were also received at this period, but were not accepted by the Secretary of State. The promotors of what is now the Indian Midland were also in the field, but got scant encouragement. Early in 1883, however, two small projects were floated, for the Tarakesur and the Rohilkhand-Kumaon Railways; the former by a local Company and without any State aid; the latter in London, with a limited subsidy from the Provincial Government. Very shortly afterwards it became clear that the money market in England was not prepared to look on Indian railway investments in the same favourable light as the promoters of these undertakings had done. The shares of the Southern Mahratta and the Bengal and North-Western fell below par, the remission by Government of its right to surplus profits above 6 per cent. did not improve the position of the latter, and, for the time, all advance of other projects was barred. Meanwhile the Schedule A of railways under construction or projected, to which I have already alluded, was put forth, dividing its 3,800 miles of line about equally between the two classes of agency. After a time the money market somewhat recovered, and Companies took up what had here been assigned to them, though on terms less favourable to the State than might have been secured by prompter action in 1881-2. Thus, in 1885 the Indian Midland and in 1887 the Bengal-Nagpur Companies were formed on terms which resemble those of the Southern Mahratta in the right of property being vested in the State, and those of the old guaranteed Companies in other respects, except that the rate of interest guaranteed is 4 per cent. instead of 5 per cent., and the share of surplus profits above that rate is one-fourth instead of one-half. Moreover, in 1888 a railway extension from Delhi to Kalka was granted to a Company which, though sufficiently secured in other ways, is professedly without any guarantee at all. This system of using both agencies appears to me to have worked well, and to be well suited for a permanence, as State debt and State establishments can be kept at a moderate level, and there will always be some railways, which for military or other reasons Government must keep in its own hands, and others with which a Company can most conveniently deal.

I must not leave this subject of agency without mentioning that in 1884 commenced a series of important changes in agency which were of a different nature, arising primarily out of the practical difficulties and friction which were found to ensue in cases where one railway Administration possessed a line to the sea-board, but its continuation or extensions up-country were in the hands of another. These difficulties induced the Government of India to propose to the Secretary of State in 1883 the transfer of the working of the Rajputana-Malwa Railway to the Bombay, Baroda and Central India Company, with the remark that they concurred in the general policy of encouraging the agency of private companies in respect of Indian railways' as set forth and vindicated by Lord Salisbury in 1877, and Lord Hartington in 1882, and that while they were not prepared to admit that experience had shown any general inferiority in the management of State railways as compared with that of private or guaranteed companies, there might sometimes be other direct or indirect advantages besides those named in that correspondence, which would justify a certain present pecuniary sacrifice in order to secure the substitution of private for State agency. The transfer was carried out early in 1884. About the same date, and for the same reasons, the contract of the Eastern Bengal Railway Company was not renewed on its termination, and the railway was amalgamated with the State lines, the Northern Bengal, and the Calcutta and South-Eastern, which existed above and below it. A similar measure was carried out in 1885-86, when the Sind, Punjab and Delhi Railway Company's contract terminated, and, for the reasons already explained, the whole was consolidated as the North-Western Railway. The question of whether in such cases the Company's railway or the State railway should be absorbed in the other has been left to depend on the individual circumstances. The latter course has been adopted in respect of the Cuddapah-Nellore Railway and its extensions to Guntakul and Dharmaveram, which are necessarily dependent in many ways on the South Indian Railway, and also of the Bellary-Kistna, which lies conveniently for administration by the Southern Mahratta company. On the same grounds the Mysore State, under the advice of the Government of India, made over to the Southern Mahratta Company, in 1886, the working of its railway, existing and projected, which was too isolated and limited to stand alone with advantage. To some observers outside, the transfers I have been referring to may have seemed to be mere capricious vacillations between one agency and another, but in reality they were all dictated by the same well-considered policy.

I have now conducted you within sight of the close of my explanation of the "Rationale of Indian Railways." You have seen how they came to be what they are in respect of their administration, their gauge, and their alignment, with its three eras of trunk lines, famine protection, and military defence. The question naturally suggests itself—What is likely to mark the decade upon which we are entering? The trunk lines, the famine lines, and the military lines have had their turn, and each is, as I have shown, now not far off the satisfaction of all its more essential needs. Is any new era likely to supervene? If one is never to prophecy unless one knows, then the only thing I can say is, that India will not get nearly as much railway extension as would be in the best interests of her Government and her people. But at the risk of being convicted of rashness, I will add that, provided military trouble stands aloof, I think we may fairly hope that a commercial era is setting in, and that railways having for their *raison d'être* the promotion of trade and public convenience may gradually obtain an increasing share of the attention of investors and of the pecuniary resources of the Government. Schedule B contains several very useful and remunerative projects, and others have been brought forward, such as the connection of Bombay and Sind through Kutch, which are much wanted. If exchange "behaves itself" so much the better, as both borrowers and investors will gain confidence. But even a low exchange has its advantages for railway construction, as illustrated by the fact that the interest on the sterling capital representing a fixed rupee outlay is, at 1s. 4d., not more than the interest on the larger sterling sum needed to cover the same outlay at 1s. 6d. There appears at present to be again considerable inclination towards Indian railway projects, which, when really well matured, are far more reasonable and reliable than many others to which the public readily turn. "The City," I venture respectfully to submit, might well study more carefully the terms upon which such projects can be floated, and should not exact in the case of India what they do not get elsewhere, but allow it to share in their spirit of adventure. On the other hand, the Government surely might more fully recognise India's want of additional railways, and the indirect as well as direct returns they yield to the State, as well as the difficulties of "the market" in financing them as yet without a moderate amount of definite support. They also need not be quite so apprehensive lest those who come forward with proposals should get a good return for their investments—a disposition certain to nip true private enterprise in the bud, as it at times has done in the past. Moreover, the commercial Members of Parliament might well give greater attention to Indian railway progress, so that well-intentioned faddists or party movers may not stand in its way. But still, at the bottom of all, must be a sound condition of Indian finance. Even under existing conditions much might be done towards furnishing revenue to be used as interest, subsidy, or guarantee for railway capital by "purging the budget account" of outlay on objects which in England would be provided for by loan. But whenever either exchange or the remittance account of the older guaranteed railways improves, and the large return (above 5 per cent.) really yielded by the State railways once more becomes—as it was in 1880-81, and some years afterwards—an item of revenue, it should not, for a time at least, be swallowed up in the general expenditure of the Empire, but should be devoted, in one form or another, to that effective and rapid railway extension which the country so urgently needs. In short, let railways breed railways. The taxpayer, instead of, with "ignorant impatience of taxation," agitating for immediate possession of these profits in order to gratify new wants, would receive the advantage of them in the form of greater facilities for locomotion and trade, increased exports, lightened exchange, improvement in land revenue, and other obvious results, thus emulating the admirable self-denial and foresight of the American people, who for so many years continued heavy war taxation in order to reduce their national debt.

My brief remaining time will now be passed in running over some of the chief places of architectural and archæological interest which a winter tourist whose tastes lie in that direction may, by the aid of recent railways, easily compass, in addition to the old obligatory points of Elephanta, Karli, Ellora, Ahmedabad, Delhi, Agra, Lucknow, Tanjore, Trichinopoly, Madura, &c.* Embarking at Bombay in one of the Sind steamers which touch at Kattiawar ports, he may land at Vairawal, close to the ruins of the famous temple of Somnath, destroyed by Mahmood of Ghazni in 1025. A new railway will take him to Junagur, the capital of the first native State in Kattiawar, close to which is the rock bearing the celebrated inscription of Asoka, B.C. 250, and two others of A.D. 151 and 457. A few miles beyond it, amidst lovely scenery, stands the sacred mountain of the Jains, Girnar, 3,500 feet high, bearing a group of ancient and highly-venerated temples. Continuing by the railway, the traveller will pass within a few miles of an equally sacred and more popular Jaina mountain, Palitana, whose summits are covered by many hundred temples, of every date from that of Westminster Abbey to the present generation, of every size and splendour up to one which cost £170,000 some 50 years ago. Here, says Fergusson, the philosophical student of architectural art may see "the various processes by which cathedrals were produced in the Middle Ages, carried on on a larger scale than almost anywhere else, and in a more natural manner." On no account should a visit to Palitana be omitted. Continuing hence through Ahmedabad, which abounds in mosques, exquisitely decorated by Hindu architects, of whose work two large perforated stone windows are a notable specimen, and touching, if time allow, at Sidhpur, to see the Rudra Mala temple (A.D. 943), the traveller reaches Abu Road. Hence he rides up to the lovely hill and lake of Abu, distinguished by a group of marble temples, comprising two of the most beautiful in India, which are covered with delicate and rich ornament of the best period of art (A.D. 1032-1247). The railway next takes him to Ajmere, where there is a mosque formed of pillars from Jaina temples destroyed by Mahometan conquerors, and from thence by a short excursion on another line to Chittore. This fortress, which fell to Alaudin in 1203, after a ten years' siege in the cause of one as fair as Helen, abounds in very ancient and beautiful buildings, of which I may name two towers, one of them is unquestionably the most beautiful tower in India, as that of the Kootub is the loftiest and finest. It belongs to the ninth century. Returning to Ajmere the railway proceeds to Jeypur, a splendid modern native capital, with its ancient stronghold, Amber, in the hills close by. Next comes Ulwur, where amid many beautiful buildings, proving that in Rajputana architecture is still a living art, stands the graceful cenotaph of Raja Bakhtawar, erected in the present century. Hence the traveller will no doubt visit Delhi, Muttra, Bindrabun, Agra, and perhaps other spots in Northern India. From Agra the Indian Midland Railway will take him to the picturesque rock fortress of Gwalior, with its Jaina temple (A.D. 1093), and on to the railway station of Bhilsa, and a group of Buddhist Topes, of which that of Sanchi is the most famous. A cast of one of its gateways stands in the South Kensington Museum. Passing through Bhopal, and over the Great Indian Peninsula Railway, from which excursions are feasible to Ajunta and Ellora, the Southern Mahratta Railway, a railway of the present decade affording rare architectural facilities, begins at Hutgi. Thence we soon reach Bijapur, a vast city ruined by Aurungzebe in 1686, replete with magnificent mosques, tombs, and palaces, among which stands pre-eminent the tomb of Mahmud, a dome structurally most interesting, which, in its internal diameter, rivals St. Peter's and the Pantheon at Rome, and surpasses St. Paul's by 27 feet. At Badami station, a short time may be pleasantly devoted to the cave temples there, and to trips to Patadkal and Aiwalli, which possess very numerous temples of the 6th, 7th, and 8th centuries. Those at the former are in the Dravidian style. Aiwalli possesses Jaina and Brahmanical caves, as also an ancient temple of Vishnu in the Chalukyan style, with apse, which is believed to be unique. The next point of interest is the extensive ruined city of Vijayanagar, also called Humpi, near Hospett station. The locality is highly picturesque, the temples numerous and extensive, in both the old and modern forms of the Dravidian style. Among the former the Temple of Vithoba (A.D. 1520) is conspicuous. Returning to the west and south by the same railway, a trip to Goa and back is replete with natural, historical, and architectural interest. Again, Guduck, Belgam, Hubli, Bunkapur, Kirwati, Lukmeshwar, Mungur, and other places on or near the line, possess interesting remains; and from Rani Bennur station the traveller who has friends in the locality may with their aid run down to the Falls of Gairsoppa, 890 feet high, with a fine volume of water. But the next really great place of interest, easily accessible from Banawara station, is the magnificent temple of Hullabeed (A.D. 1310), with Belloor and Hurulhullee in its immediate vicinity, comprising the finest examples of the Chalukyan style. Replete with splendid temples as is Southern India, it would be beyond my text to wander there. By one route or another the visitor of Southern India can eventually return to Guntakul junction of the Madras and Southern Mahratta Railways, and may proceed thence by a picturesque descent of what may be termed the Eastern Ghats, to Bezwara on the sacred Krishna. Within a short distance are the remains of Amravati, which, with Bhilsa, already noticed, and Manikyala in the Punjab, constituted the great triad of Buddhist topes in India. Unfortunately, far more may be seen and understood about it in the South Kensington Museum, and the pages of Fergusson's "Tree and Serpent Worship," than on the spot. The locality has, however, various forms of interest, and the Nizam's new railway offers a pleasant return by his capital, with Jaina buildings at Warangal on the way.

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* The places mentioned were illustrated by lantern slide projected on the screen.

From what the time available has allowed me to say, it will have been gathered that the new railways have most materially assisted the architect and archæologist. In fact, the facilities throughout India are now so great that he might spend a year or more with equal profit and delight.

DISCUSSION.

Sir JULAND DANVERS, K.C.S.I., said he had listened with very great interest to this valuable paper, and could find no excuse for starting any controversial discussion; he could agree with almost every word of it, the exception being the introductory sentence, in which allusion was made in too complimentary a manner to his own attempt to bring the subject before the Society a year ago. There was also an omission, due no doubt to the modesty of the writer, inasmuch as he had made scarcely any reference to the very active part he had himself taken in connection with Indian railways. The system which, he truly said, had been during the last ten years much enlarged and more completely organised was, in great part, due to the energy, perseverance, and far-seeing statesmanship of Sir Theodore Hope, during the five years when, under the administration of Lord Ripon and his successor, he fulfilled the duties of Public Works Minister. His great objects during that period were the security of India, the development of her resources, and the protection of the country from famine; and in endeavouring to accomplish them he spared himself neither mentally nor physically. In the far West and in the far East his presence was seen and felt. During his tenure of office upwards of 5,000 miles of railway were approved and commenced, in addition to the 10,000 which had been constructed when he took office. One very important feature referred to was the growing interest now being taken by the rulers of native States in the introduction of railways into their territories. There was no doubt that they would soon see, if they had not already discovered, that prosperity, civilisation, and contentment would follow the railway train. Much had been done already, but he hoped much more would be done. General Trevor, who was chairman of the Bombay and Baroda line, was strongly in favour of encouraging the native States in the neighbourhood of that line to join in developing their systems, and he trusted he would succeed in going farther in that direction. He entirely agreed in the view that State action and private enterprise should work concurrently; there was ample room for both, and neither should be excluded. At the same time, he quite appreciated the difficulties of a large State system; it led, as Sir Theodore Hope stated, to the growth of a great and expensive permanent establishment, to an increase of the public debt, and, above all, to a costly uncertainty as to the provision of funds; and, in addition to that, he would say, it was important that the Government, as owners of railway property, should not allow that position to conflict with their position as guardians of the general interests of the country; they should not be tempted as owners of a particular railway to oppose the construction of another which, although much needed, might be regarded as a competitor. It had been suggested that railways might breed railways, and that phrase struck him as being very apt. Nature was a useful guide in many things, and he did not see why she should not be followed in this respect. In the beautiful architectural illustrations which had been shown, in the construction of the spire, the arch, and so on, Nature had been imitated, and it seemed to him wise to follow her example when dealing with railways, and to allow parent lines to propagate offspring. A railway which had become flourishing was in a position to create other lines, and produce a family or group, the individuals of which helped each other, and made what was already valuable ten times more so. The famine lines had become a very important feature in recent railway administration, and their value, taken from only a purely financial point of view, could hardly be over-estimated. In this country, to protect our poorer people from famine, something like £8,000,000 a year were expended, and it was not an extravagant idea to propose that railways should be made for famine purposes in India, which would not probably exceed a charge on the revenue of the country of a few thousands a year. These lines, it should be remembered, besides averting the dreadful effects of famine, developed the productive resources of the country, and might also be useful as strategic or military works. The question of gauge, which was too apt to lead to a battle ground, he would not venture to discuss now. He would only say that, having two gauges, the object should be to make break of gauge as little inconvenient as possible. He hoped greater progress in railway construction would be made in the next ten years than in the last. The authorities, of course, were anxious that private enterprise should step in, but, unfortunately, private enterprise did not seem disposed to come forward without some Government aid, and when that had to be given, it was generally found either that a simple system of guarantee was a more economical arrangement, or that the Government should make the lines. But there was great scope for private enterprise in India, and he did not see why capital should not flow more freely in that direction. It might be an encouragement to remark that last year, although the traffic was not very good, taking the good and bad together, Indian railways produced a return of nearly 5 per cent. on the capital employed.

Mr. E. Walford said that, as Sir Theodore Hope had mentioned the possibility in the future of railway extension in India by means of private enterprise, he would like to say a few words on that subject. The two lines first introduced without guarantee by the Indian Government turned out rather unfortunate, and that had led to a disinclination on the part of investors. The prospectus of the Bengal Central, which was issued by the two leading financial houses in London, contained an estimate of the traffic which emanated from one of the Government departments, and which showed a probable net return of about 12 per cent. on the capital. The public subscribed freely, and the shares went to a premium, but unfortunately the traffic turned out very much less than had been anticipated, insufficient, in fact, to pay working expenses, and ultimately the Government gave the shareholders a guarantee of 3 per cent. The next, the Bengal and North-Western, turned out a success, and so did the Rohilkund, but that had a sort of modified subsidy. The public were accustomed to a guarantee, and would not invest in Indian railways unless they were educated up to it.

The fact is, no new Indian railway can be expected, owing to the difficulty of developing traffic, to earn any dividend on its ordinary stock for the first three years it is opened; and he would suggest that the Government should offer to the public some of the established railways in their hands (not military lines, of course) on favourable terms, and when investors had become accustomed to railways without a guarantee, they would be more likely to find money for new schemes. The money received would be a great service to the Government, and being received in sterling would relieve the loss on exchange.

Mr. W. Martin Wood said no one could question the ability shown in this paper, or the immense amount of information it contained, but it had entirely missed one point which was essential in the *rationale* of the Indian railway system, being sublimely regardless of the question of expense. That point required serious consideration, the total cost being, he believed, about £200,000,000. There were several important points in connection with that which should not be overlooked; for instance, what had been the charge on the Indian revenues for interest and other charges not recouped? In 1884-5 that was £41,000,000, and it must be more now. With regard to the military or trans-frontier railways, it was true they were magnificent engineering works, but they were beyond the bounds of India altogether, and what had they cost? It was desirable that the different kinds of railways should be discriminated. The guaranteed railways cost about £50,000,000; the State railways under company management, £22,500,000; and the State railways, £127,000,000. All these military lines were purely State railways, and it would be interesting to know what that portion had cost. Justification had been sought in the complications which arose on the North-Western frontier and to the Afghan War, but history plainly told them that these complications were deliberately invited and provoked; they did not spring out of the dust, but from the actions of men, and in pursuance of a most destructive line of policy. One essential factor in the *rationale* of Indian railways was that of the general question of alignment. In a peninsula like India, railways should run transversely from the coast to the interior, so as to have the greatest practical effect on export and import traffic; and he would ask in that connection how a line from Madras to Calcutta, parallel with the coast, could be supported? He was rather relieved to hear what was said with regard to the Bengal and Nagpur line, and that Sir Theodore Hope laid great stress on the extension to Cuttack; but it was manifest to anyone who looked at the map, that it was a great mistake to take a line through the middle of Bengal, up to the Hooghly, instead of going direct to the coast. It had been remarked incidentally that canals were only applicable to a small part of India, but he thought that was begging the question. If English engineers could not design effective canals there were plenty of men on the Continent who could, and so could Indian engineers if they were properly trained. It had been said that the extension of railways economised military expenditure; but they knew how utterly vain that was, for as the railways extended the military expenditure increased also in a greater ratio than ever; in 1856, it was 12½ millions, and now it was over 20 millions. That was the inevitable effect of going beyond the frontiers. There was a letter in *Allen's Indian Mail* (December 10th), referring to these railways on the frontier, and pointing out that the ordinary camel and mule traffic was still in use through Beluchistan to Kurrachee, the railway charges being prohibitive. It could not be contended that these railways beyond the frontier would even pay their working expenses. Sir Theodore Hope seemed to be of opinion, with regard to the gauge, that there would be another revolution back again; and on that point he might quote these remarks made by General Trevor at a railway meeting:—"The idea in high Government circles in India is to discontinue metre gauge construction, with the intention eventually of again obtaining a uniform gauge throughout India by gradually changing the existing metre gauge lines into broad. This reversal of policy will involve a tremendous waste of public money, probably about twenty millions sterling, as the change will cost about £3,500 a mile, and outside Burmah there are over 6,000 miles of metre gauge road. It will also retard the provision of railways in India even more than the previous change from broad to metre has already done, and this was no small evil, as those who have administered the Railway Department in India, as I have done, know to their cost. This expenditure, which will bring in no additional revenue, would be sufficient for the construction of about 5,000 miles of new metre gauge railways—railways that would greatly develop Indian resources, as well as protect the people in millions from famine." These financial questions ought to receive more attention than they did, for, as he once heard Sir R. Temple say—when speaking of railways—"I know my countrymen, Englishmen are very lavish;" but they had no right to be lavish with other people's money; though all were proud of the energy and engineering skill described in the interesting paper they had listened to.

Mr. Noble Taylor having held, though more than twenty years ago, the post of Public Works Member in the Indian Council, which Sir Theodore Hope had so recently relinquished, had listened to this paper with great interest and pleasure; and especially to the closing remarks with regard to the future extension of railways. During twenty years, about 12,000 miles had been constructed, and during the last nine or ten, about 6,000; but what were 17,000 miles of railway in a vast empire like India? In reply to a question in the House of Commons, the Under Secretary of State recently said the policy of the India-office continued to be that railways should be extended so far as the finances of the country would permit, and that seemed reasonable enough; the authorities were bound to keep a fair balance between income and expenditure. But a broader view must be taken of the obligations of the Government in this matter; the provision made for the development of railways in India scarcely kept pace with the requirements of the country. There were cries from all quarters for further extension, and if the Government were unable to cope with the demand without assistance, they should invite the co-operation of private enterprise. There was a disposition to do so, no doubt, but action was uncertain for want of a definite plan. Some clear comprehensive scheme was wanted, based on the requirements of every part of India, so that companies and promoters might shape their proposals accordingly, whether the standard or metre gauge were adopted. There were now about 10,000 miles of the one and 7,000 of the other, and it was important that the systems should be localised, and that one guage should not be introduced into a country occupied by the other, a principle which had been too often disregarded. Break of gauge on a main line was always disastrous, and could not be tolerated in the present day. Sir C. Elliott, the present Public Works member, in a speech delivered during the Budget debate in the Legislative Council, remarked that it was not the policy of the Government to encourage the employment of guaranteed railways of the old class—though it must be remembered that to them the present prosperity of India was largely due—"because," continued Sir Charles, "if the Government can raise the required capital on its own credit at 3 per cent., it is useless to ask a company to borrow for it at a higher rate." This was quite true; but companies would be assisted in a variety of ways, for without encouragement of some sort private capital will not flow in any volume for investment in railways in India. The construction of railways was not undertaken by private capital unless there was a reasonable prospect of return, but with a Government like that of India the case was different. The deciding motive ought not to be direct pecuniary profit; the indirect advantages to the State of facility of transport were incalculable; the increase in the value of land, in the wealth of the people, and in the general prosperity of the country, and the consequent improvement and greater economy in every branch of administration would amply repay the outlay. He hoped, therefore, that a bolder and more comprehensive policy would be pursued in future, so that railway extension in India might proceed more rapidly than heretofore.

The CHAIRMAN said the Society was much indebted to Sir Theodore Hope for the valuable exposition he had given of Indian railway policy. He had not, of course, dealt with all the aspects of that policy, and had not referred to the financial side of it; had he done so they would have been kept there until next morning. On that point he (Lord Ripon) would merely say that the Government of which he was the head, and Sir Theodore Hope a distinguished member, paid a careful regard to the financial aspect, and had not the smallest desire to run into expense which was not justified. He entirely agreed that nothing could be more reprehensible than that certain classes of lines should be undertaken recklessly, and without regard to the financial capabilities of the country; but he was bound to say with respect to what had been called protective lines, designed to afford protection against famine, the pressure of the necessity for their creation always seemed to him very great indeed. It was his happy fortune not to have any famine to deal with during his term of office, but it always appeared to him that those years of rest, which, judging by past experience, could not be indefinitely prolonged, were the proper period for doing the utmost that the financial condition would permit, to supply by means of railways, the best security against the worst evils of future famines. The Famine Commission said that 5,000 miles of railway were required, and though the result fell short of that, a considerable approach had been made to it under the management of Sir Theodore Hope. The development of the country and its industries was an important feature of any scheme of railway construction in India; but there the financial conditions came in much more strictly, because although commercial development was of the utmost importance, there was not that imperative call for immediate measures as there was in the case of provision against famine. It was especially in the case of these commercial lines that they might fairly look to the assistance of private enterprise. His Government were anxious to resort to that as much as possible, but they did not receive as much encouragement as they had hoped. It was not impossible that too stringent terms might have been demanded in England from those willing to undertake works on reasonable conditions, and, if that were so, it was a shortsighted policy. Again, with regard to the military lines, which were determined upon before the end of his connection with India, he could assure the meeting that it was with great regret that he had a hand in diverting a large portion of the Public Works expenditure to railways of that kind; he would much rather have completed the protective railways or developed the resources of the country; but he did believe there was a necessity for those lines, because in the first place they would afford a large amount of security in case of any hostile intentions, and they would also render a small army more powerful and more available than if there were no such lines. He believed it was better to lay out money in the construction of these lines than to greatly increase the annual military budget, as this was an expenditure once for all; when made they would be a defence for ever, and then they could look with comparative calmness on many of those political incidents which otherwise would be apt to create panic. Many of such panics had been unwise and unnecessary, but they were a fertile source of expense. He would not go into the vexed question of the gauge; he had never been a special advocate of either one or the other, but he quite agreed with Mr. Taylor that break of gauge was much to be deprecated. He must express his great admiration for the remarkable engineering works in connection with the railway over the Amran Range, which had been completed since he left India. They were amongst the most remarkable works of the kind in the world, and reflected the greatest credit both on Sir J. Brown and Mr. O'Callaghan, who carried them out under the superintendence of Sir Theodore Hope. He would conclude by formally moving a hearty vote of thanks to the latter gentleman for his valuable paper.

Sir THEODORE HOPE said it was not necessary to reply in detail to the very mild and kindly criticisms which had been passed on his paper. They had mostly been noticed by previous speakers. He had not referred to the question of cost, because, as he said at the outset, Sir Juland Danvers had already supplied full information on that subject. On the burning question of gauge, he did not think he had said anything which would give anyone the right to suppose that he advocated any general alteration of gauge throughout India; on the contrary, he deprecated any such scheme. The remark which probably gave rise to that impression was with reference to the Rajputana Railway, and to that he adhered; but the Rajputana, though a great line, was not the whole of India.

Miscellaneous.

THE PRODUCTION OF ALFA.

It is stated in a recent memorandum on the subject of the production of alfa, prepared by one of the professors of the Medical College at Algiers—and quoted by Sir R. L. Playfair, her Majesty's Consul-General at Algiers, in his last report—that the Arabic word "halfa," vulgarly alfa, is applied to several plants of the genus *Stipa*, but for all ordinary purposes it is limited to *S. tenacissima*, which is found over a great extent of country in the south of Spain, Morocco, Algeria, Tunis, and Tripoli. Another species, the *Stipa arenaria*, or *macrochloa*, is found in Spain, and is principally used for the manufacture of coarse articles known as *Sparterie*, such as baskets, cord, &c., and is much less esteemed than the Algerian species, which is also exported from Spain. It grows from the sea level up to an altitude of 1,800 mètres; it delights in heat and drought sufficient to kill almost every other plant, and in undulating land where water cannot lodge. In Morocco it occupies an immense region, from the high plateaux, which are a continuation of those of Dran, almost as far as Tangiers; but it is also gathered near Mogador. It is found in the south of Portugal, in a province more arid than the rest of the country—that of Algarve. In Spain it covers a large space on the plateaux, within a triangle of which the three points are Malaga, Valencia, and Madrid. It abounds in the province of Murcia and Almeria (near Granada), Huescar, Guadalajara, Albacete, Toledo, and in other places. In Algeria it extends from the littoral of Oran to the Ksours and the plateau of the Oulad Sidi Checkh, south of a line passing through Sebdon, Daya, Saida, and Frenda. In the department of Algiers it does not reach the littoral, nor does it occur in any region where the rainfall is, on an average, as much as 60 centimètres per annum. The phases of vegetation of alfa are as follows:—In the commencement of spring the old leaves enter on a period of activity, profiting by the first return of warm weather. The young leaves, which began to appear in autumn, are developed, burst forth, and the functions of vegetable life attain their maximum of intensity. About the end of April or the beginning of May the flowers appear, and by the middle of June the seeds are ripe. The fecundation of the seed is very irregular, the stamens are rich in pollen, and the ovaries are well developed; but many of the flowers seem absolutely sterile, and the seed vessels dry up without reaching maturity. The seed which does ripen is carried, often to a great distance, by the dry wind of summer, and commences to germinate after the first rains of autumn. It requires five or six years for the young plant to attain its normal height, and nearly fifteen years before it can be plucked. But nature, it is said, has a much more expeditious way of renewing the plant by rhizomes, which often travel a considerable distance in the sand and throw up new shoots, generally in a circular form, round the old plant, each of which in time becomes a centre for still further propagation. The cultivation and artificial propagation of alfa has been attempted in Spain, but never in Africa. Both in Spain and in Algeria the period for gathering alfa is fixed by law. In the latter country there is a close time from January 1st to June 30th, subject, however, to modification according to circumstances. In Morocco, Tunis, and Tripoli there is no restriction whatever. The usual method of plucking the plant is by means of a stick 40 centimetres long, which the gatherer attaches to his left hand by a leather strap; he seizes with his right hand a packet of leaves, turns them round the stick, and pulls them out with both hands. Spaniards are far more adroit at this work than Arabs, and gather much more during the course of the day, but they injure the plant more seriously than the Arab. The average amount that workmen can collect of green alfa is about as follows:—Spaniards, from 300 to 400 kilogrammes; Arabs, from 150 to 200; women or old men, 100; and children from 12 to 13 years, from 35 to 40 kilogrammes. The green alfa, when plucked, is placed upright in small bundles to dry, an operation which does not require more than from three to four days. The fibre loses from 18 to 40 per cent. of its weight during the operation. It is then transferred to depôts, where it is sorted and classed according to its length; the longest fibre is reserved for the manufacture of sparterie, the shorter is used for paper. The best qualities sometimes average about 50 per cent. of the entire quantity, but at other times it is as low as 1 per cent. The various kinds are then pressed by hydraulic machinery, bound with iron bands, and sent off to the port of shipment. There is no doubt that during the past twenty years the amount of alfa plants has been steadily decreasing, and in some places where it was formerly found, there is no trace of it remaining. This is principally due to the custom of collecting it during the period of vegetation and by unskilful manipulation of the plant. The various countries which export alfa are, Spain, where it has been in use for ages. The exportation from 1868-72 amounted to 90,000 tons annually, now it is reduced to 45,000 tons. In Algeria the export commenced in 1863, in 1870 33,000 tons were exported; the maximum 110,000 tons was attained in 1879, now it is about 80,000 tons. Tunis exported about 33,000 tons in 1879, now 100,000 tons are exported. Tripoli exported 80,000 tons in 1881, the production may now be stated at 75,000 tons. Morocco only exports about 3,000 to 4,000 tons from Mogador. During the past few years the aggregate exportation of alfa from the above-mentioned countries has been increasing, whereas the demand for it has shown a tendency to decrease. From 1860 to 1869 the total exportation was not more than 95,000 tons, in 1876 this had nearly doubled, in 1881 it was 200,000 tons, and in 1887 225,000 tons. Every day wood pulp is becoming more used and employed with increased effect, not only in the manufacture of paper, but of various other substances formerly made chiefly from alfa. It is the manufacture of paper which consumes the greatest part of the alfa exported from the countries which produce it. Thus out of the 225,000 tons exported, 210,000 tons are said to be destined for that industry. The United Kingdom is the principal market, and takes 200,000 tons, the small remainder is purchased by France, Germany, and Belgium. The quantities sent to Italy and Austria are hardly appreciable.

TOBACCO CULTIVATION IN THE MADRAS PRESIDENCY.

Tobacco is found more or less throughout the Madras Presidency, with the exception of Malabar and the hill ranges; but the chief localities of production are the alluvial lands of the Godavery district, where is grown the well-known *Luntra* tobacco (so named from the luntras or river islands on which it is cultivated) and parts of the Coimbatore and Madura districts, from which the Trichinopoly cheroot manufacturers draw their supplies of raw material. The plant, says the "Manual of Administration of the Madras Presidency," is grown on almost every description of soil, from black loam to sand, and from irrigated land to high arid sites. Alluvial lands are preferred and then high ground, and such places as deserted village sites and back yards of houses—the latter on account of the salts impregnating the soil, and also probably for convenience of position as regards manuring and watching and curing the product. Of the more esteemed tobaccos used for European consumption, the best of the Godavery produce is grown on these alluvial lands, which receive rich deposits of silt in the river floods and are out of the influence of the sea-freshets, while the Dindigul tobacco is produced on a carefully cultivated red loam, to which an alluvial character has been artificially imported. Some of the highest priced tobacco is grown on rich dry land under irrigation; but this, while suited for chewing, is too coarse in texture of leaf, and too pungent in flavour for smoking. In some parts irrigation is practised, and in others it is dispensed with. Only a small quantity of water is supplied to the plant, and as a rule not by gravitation but by mechanical appliance, and preferably from wells of brackish water containing potassic salts. Excessive damp is prejudicial, and the seed beds and soil generally are superficially drained or stand high. The crop while young is gently watered by hand, and heavy rains detract from the quality of the tobacco, the tobacco grown on ordinary irrigable lands being generally inferior. The manures used are generally the droppings of sheep and goats penned on the land previously to cultivation, and cattle dung and urine, ashes, and sweepings. In Nellore salt earth is used. The manures are plentifully applied to all soils except alluvial lands. The seed is invariably sown in seed beds, and the seasons of cultivation vary according to local climatic considerations. As a rule sowing commences after the local rains, from July to October, although tobacco is sometimes grown as a second crop, commencing in January. The site of cultivation is thoroughly ploughed and manured; the seed germinates in some eight days after sowing, and the seedlings are transplanted in the course of about six weeks, on attaining a height of five or six inches, into holes a foot to a yard apart, sometimes in ridges, sometimes on the flat surface of the field. In some localities the seed beds and young plants are protected from the extreme heat of the sun by means of mats, &c., and all leaves, except ten or twelve, are nipped off to strengthen those left. The flowers are also promptly nipped off, with the exception of those purposely left for seed. The leaves begin to ripen in the course of about two months from transplantation, and as soon as one or two turn colour the whole crop is gathered. This is effected generally by cutting the stem with a knife, although in Gaujam and the alluvial lands of Vizagapatam the leaves are nipped off separately, and in part of Tanjore some leaves are first plucked in January, and the stem and remaining leaves cut down in May or June. As a rule, no second crop is gathered, and where the after sprouts are collected at all, they are of very inferior quality. The process of gradually drying and fermenting is effected by methods slightly differing in detail. In Nellore, for example, the cut leaves are hung in the sun for two days, placed in heaps, turned every two days, and ranged in layers for twenty days, during which time they are frequently turned. They are then tied in bundles, dipped in water, sweetened with date jaggery, and are then ready for sale. In other parts, as in the Salem district, the plants are left a day or two in the field, then exposed to the sun and dew alternately for a week, then wrapped in straw and buried in the ground for a week, after which the leaves are stripped from the stem, made into bundles, placed in straw, and put under heavy weights with their ends exposed for six weeks, the piles in which they are laid being opened and turned every other day. In other localities the leaves, after drying in the fields for a day or two, are hung over poles or ropes, preferably in the shade, in regular drying-sheds or in the cultivators' houses, and subsequently stacked in heaps, which are opened out and pressed together again at stated intervals until the requisite curing is effected. Occasionally the leaves are sprinkled with jaggery water or an infusion of the *Cassia auriculata* while drying, and in Coimbatore the festoons of leaves, after being strung, are hung up on the milk hedge *(Euphorbia tirucalli)* to acquire thence a flavour. State interference has been suggested in the case of this industry, but the Government has decided otherwise.

Notes on Books.

A SMALLER COMMERCIAL GEOGRAPHY. — By George G. Chisholm, M.A., D.Sc. London: Longmans, Green, and Co. 1890. Sm. 8vo.

This is to a great extent an abridgment of the author's "Handbook of Commercial Geography," and is intended as a school text-book. Tables of exports and imports have been omitted, but the facts to be learned from these tables are summarised in the text. The introductory portions of the book are devoted to the consideration of commodities and the circumstances affecting their production and carriage, and descriptions of the various countries of the earth follow. Under the different countries particulars are given as to areas, surface, and communications, climate, agricultural products, minerals, manufactories, foreign commerce, &c.

URBAN RATING; being an Inquiry into the incidence of Local Taxation in Towns, with special reference to current proposals for change. By Charles Harry Sargant. London: Longmans, Green, and Co. 1890. 8vo.

The subject dealt with by Mr. Sargant is the rating of ground-rents, and the treatment it receives will be seen from the titles of the chapters. (1) Origin and nature of ground-rents, (2) the determination of ground-rent, (3) have ground-rents already paid rates? (4) proposals to rate, (5) rating as between building owner and occupier, (6) rating between building owners and owners of fixed rents, (7) rating between building owners and the owners of reversions, (8) rating of vacant building land.

SCHOOL HYGIENE. By W. Jenkinson Abel, B.A. London: Longmans, Green, and Co. 1890. Sm. 8vo.

This little book is intended as a manual for the use of teachers and others, telling them what to do, and how to do it, in case of diseases, accidents, &c., coming under their notice. The subjects are disinfection, eyesight, infectious diseases, school surgery, poisons, and colour-blindness.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JUNE 23...Medical, 11, Chandos-street, W., 8½ p.m.

Asiatic, 22, Albemarle-street, W., 4 p.m.

Victoria Institute (At the HOUSE OF THE SOCIETY OF ARTS, John-street, Adelphi, W.C.), 8 p.m. Mr. Hormuzd Rassam, "The Site and Geographical Position of some of the Earliest Recorded Places in Holy Writ."

TUESDAY, JUNE 24...Statistical, School of Mines, Jermyn-street, S.W., 5 p.m. Annual General Meeting.

Anthropological, 3, Hanover-square, W., 8½ p.m. 1. Mr. John E. Price, "Notes, with Exhibition, on a Skeleton found at West Thurrock, Essex; and Two Skulls recently exhumed within City Limits." 2. Mr. H. H. Risely, "The Ethnology of India."

Colonial Inst, Whitehall-rooms, Northumberland-avenue, W.C., 9 p.m. Conversazione at the Natural History Museum, S.W.

WEDNESDAY JUNE 25...SOCIETY OF ARTS, John-street, Adelphi, W.C., 4 p.m. Annual General Meeting.

Cymmrodorion, 27, Chancery-lane, W.C., 8 p.m. Conversazione.

Royal Society of Literature, 21, Delahay-street, S.W., 1 p m.

FRIDAY, JUNE 27...SOCIETY OF ARTS, 9 p.m. Conversazione at the Natural History Museum, South Kensington.

United Service Inst., Whitehall-yard, 3 p m. Prof. V. B. Lewes, "Spontaneous Combustion and Explosions in Coal Bunkers."

Browning, University College, W.C., 8 p.m. Paper by Dr. Stanton Coit.

SATURDAY, JUNE 28...Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

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FRIDAY, JUNE 27, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CONVERSAZIONE.

The Society's conversazione will take place at the Natural History Museum, Cromwell-road (by permission of the Trustees of the British Museum), this evening, Friday, 27th June.

Proceedings of the Society.

ANNUAL GENERAL MEETING.

The Annual General Meeting for receiving the report from the Council, and the Treasurers' Statement of Receipts, Payments, and Expenditure during the past year, and also for the Election of Officers, was held, in accordance with the Bye-laws, on Wednesday last, the 25th instant, at four p.m., the Duke of Abercorn, C.B., Chairman of the Council, in the chair.

The Secretary read the notice convening the meeting, and the minutes of the previous annual general meeting.

The following candidates were proposed, balloted for, and duly elected members of the Society:—

Bennett, Francis James, 28, Jermyn-street, S.W.
Blyth, Sir Arthur, K.C.M.G., C.B., 15, Victoria-street, S.W.
Chadwick, Andrew D., 88, Canfield-gardens, West Hampstead, N.W.
Danvers, Frederick C., India-office, S.W.
Dimsdale, John, 50, Cornhill, E.C.
Donne, William, 18, Wood-street, E.C.
Eaton, Edmund Octavius, B.A., B.Sc., 27, Martin's-lane, Cannon-street, E.C.
Erskine, R. S., 68, Sydney-street, Onslow-square, S.W.
Farquharson, J., Woodland's-cottage, High-street, Acton, W.
Froude, Robert Edmund, 1, Claremont, Alverstoke, Gosport.
Galloway, Charles John, Thorneyholme, Knutsford.
Gorham, John M., 66, Victoria-street, S.W.
Hall, Capt. Robert Gresley, St. John's-wharf, Wapping, E., 22, Commercial Sale-rooms, E.C., and 60, Avenue-road, Regent's-park, N.W.
Hawtrey, Walter, 35, Cannon-street, E.C.
Hill, William Becket, 103, Leadenhall-street, E.C.
Hollams, John, 52, Eaton-square, S.W.
Hope, Sir Theodore Cracroft, K.C.S.I., C.I.E., 21, Elvaston-place, S.W.
Hyslop, S. James, 8, Liverpool-street, Dover.
King, John Langley, South-view, Church-hill, Walthamstow, Essex.
Lanaway, Hugh, London and County Bank, Dunstable.
Lewes, Prof. Vivian Byam, Royal Naval College, Greenwich, S.E.
Lucey, Frederick Samuel, 110, Cannon-street, E.C.
Macdonald, General John, 31, Lansdowne-crescent, Cheltenham.
Machin, Frederick, Ismeer, Willesden, N.W.
Maclear, Captain John Pearse, R.N., Cranleigh, Guildford, Surrey.
Manuelle, Frederic, 100, Queen's-gate, S.W.
Mathers, Edward P., Warnford-court, E.C., and Glenalmond, Westwood-park, Forest-hill, S.E.
Medley, Lieutenant Allan, 77, Elsham-road, Kensington, W.
Miller, John Smith, Hyson-green Works, Nottingham.
Murphy, George Stormont, 46, Cambridge-terrace, Hyde-park, W.
Orfeur, Norman, Braintree, Essex.
Pertwee, William Hart, Seaton-lodge, Lyloan-road, Wanstead, Essex.
Posno, Charles Jaques, 19, Finsbury-circus, E.C., and The Woodlands, Grove-park, Lee, S.E.
Raffety, William John, National Liberal Club, Whitehall-place, S.W.
Rutherford, V. H., B.A., M.B., 6, Eldon-square, Newcastle-on-Tyne.
Rutley, Frank, 93, Edith-road, West Kensington, W., and 28, Jermyn-street, S.W.
Saillard, Philip, 87, Aldersgate-street, E.C.
Sandeman, Albert George, 32, Grosvenor-street, W.
Simpson, John, Wirksworth, Derbyshire.
Smith, Armstrong, Honolulu, Hawaiian Islands, and Cosham, Hants.
Tritton, Joseph Herbert, 54, Lombard-street, E.C.
Turner, Benjamin, 50, Bartholomew-close, E.C.
Turner, Sir Charles A., K.C.I.E., 29, Palace-gate, Kensington, W.
Tyler, Charles, Elberton, New West-end, Finchley New-road, N.W.
Tyler, J. J., 7, Evelyn-gardens, W.

Wade, Paget Augustus, 34, Fenchurch-street, E.C.
Wünsch, Edward A., Carharrack, Scorrier, Cornwall, and Glasgow.

The CHAIRMAN nominated Mr. Henry Maudslay and Mr. Major Hawkins scrutineers, and declared the ballot open.

The SECRETARY then read the following—

ANNUAL REPORT.

I.—ORDINARY MEETINGS.

The Session commenced, as usual, with an address from the Chairman of Council, the Duke of Abercorn. In his address the Duke dealt with the history of the Society of Arts, reminding the members of the various directions in which it has worked since it was founded 136 years ago; and indicating some of the directions in which its energies might now most usefully be applied, even though so much of the work which it has initiated has since been taken up by bodies specially constituted, and devoting their attention to more limited fields than that which belongs to the Society of Arts.

At the first meeting after the Opening Meeting Dr. Gladstone read a paper on "Scientific and Technical Instruction in Elementary Schools," in which he again brought before the Society a subject he had dealt with eleven years previously, showing how much had been done, and how much remained to do. Dr. Gladstone's remarks were usefully supplemented by some observations of Mr. Mundella, who was in the chair, and who contrasted the advance which had been effected in France in recent years with the comparatively slow progress which had been made in this country. On the following Wednesday Dr. Armand Ruffer, in an able and most temperate paper on "Rabies and its Prevention," brought before the Society the most recent investigations of Mons. Pasteur, and their practical results, showing how one of the most terrible diseases, long looked upon as hopelessly incurable, has been brought within the power of medical science. The next Wednesday evening was devoted to a paper by the Secretary of the Society upon the "Paris Exhibition," in which a sketch was given of the organisation of the Exhibition generally, and a summarised account of the British Section, which was shown to have been on the whole superior to that of any country other than France, notwithstanding the very great difficulties with which the voluntary committee that undertook its organisation had to contend. The proposition for the holding of an Exhibition in London about 1895, and the suggestion of Regent's-park as a locality, may perhaps bear fruit in the future. The next paper, by Sir Robert Rawlinson, K.C.B., on "London Sewerage and Sewage," gave rise to a long and important discussion, a second evening being devoted to it. The method of dealing with London sewage advocated by Sir Robert Rawlinson would be the construction of a sewage conduit, or conduits, from London to the Maplin Sands, these conduits being capable of being tapped for the supply of sewage to some forty-four miles of agricultural lands through which they would pass; farmers having the option of using the sewage for irrigation at such times and seasons as they might require it.

The above were all the papers before Christmas, the discussion on Sir Robert Rawlinson's paper, indeed, being taken at the first meeting after Christmas. Mr. Brudenell Carter's paper on "Practical Vision-testing"—the first read in the new year—dealt mainly with the practical application to the testing of railway signalmen, sailors, and others, of the results of investigations in colour-blindness and imperfect vision, which Mr. Carter has dealt with before the Society in his paper on "The Influence of Civilisation upon Eyesight," given in 1885, and in his Cantor Lectures on "Colour Blindness," delivered in 1881. Mr. Brudenell Carter, like all those who have studied the subject from a scientific standpoint, is an earnest advocate for the testing of the vision of those on whose keenness of sight the safety of others must depend, and he showed how this testing could be accomplished by the ingenious method of Holmgren, combating the objections which an imperfect knowledge of the method had induced many practical workmen to put forward.

In his paper on "The Utilisation of Slag," Mr. Gilbert Redgrave gave the most recent information as to the progress which has been made in the solution of a problem which has for a long time vexed our iron manufacturers, and showed that considerable progress has been made since 1880, when the subject was treated before the Society by Mr. Charles Wood, of Middlesbrough. On the following Wednesday evening Mr. Arthur Paget gave an account of the ingenious stockinette machine which he has invented. This is really a knitting machine, and the process may, perhaps, be most simply described in the words of the inventor as "weaving without weft." The machine is capable of turning out fabrics of the most different character, from a closely-made cloth to a "cloud" for ladies' wear, or a fishing-net, or even a piece of wire-netting. By means of a most ingenious model, 32 times the full size, the process, complicated as it appears except to experts, was made thoroughly clear to those who attended the meeting.

The next paper was an important one by Mr. George Findlay, in which an account was given of "Modern Improvements and Facilities for Railway Travelling." A month later, Sir Douglas Galton, who was in the chair at Mr. Findlay's paper, himself read a paper on a kindred subject—the "Chemin de Fer Glissant, or Sliding Railway." In this railway the train, instead of being supported on wheels, rests on sledges, or "shoes," which slide on a film of water maintained between them and the rails, the propulsion being effected by hydraulic power. The invention is certainly of a most novel character, and is very ingenious. How far it will be successful in practice can only be proved by the test of experiment. A short length of railway was successfully worked at the Paris Exhibition, another is now working in Edinburgh, and a longer line is, it is stated, about to be laid down for experimental purposes near Willesden.

Besides Dr. Gladstone's paper, already referred to, two papers on technical education were read during the Session, one by Professor Silvanus Thompson, on the "Organisation of Secondary and Technical Education in London," and one by Dr. Percy Frankland, on the "Higher Technical Teaching." Dr. Thompson criticised somewhat severely the action of the Charity Commissioners, and the way in which they proposed to deal with the large sums which have come into their hands from the City of London Parochial Charities. Dr. Percy Frankland impressed upon us once more how much more liberal foreign countries are in the provision of higher technical education than we in England.

In his paper on "The English in Florida," Mr. Arthur Montefiore gave an interesting account of the present condition of that State, and of the opportunities it affords to persons possessed of a little capital, and willing to employ themselves in farming pursuits under conditions apparently more favourable than now prevail in the old country.

The horological exhibit at the Paris Exhibition formed the text of Mr. Tripplin's paper on "Recent Progress in British Watch and Clock-making," and the account given by him of the distinct advance which late years have seen in this important industry was decidedly satisfactory. Another paper drawing much of its inspiration from the Paris Exhibition was that by Mr. G. N. Hooper on "Carriage Building and Street Traffic in England and France." With regard to the industry of carriage building, there is certainly no doubt that our foreign rivals, not many years ago distinctly inferior to the carriage builders of this country, are beginning to run us very close. In his paper on "The Bearings of Geography on Commerce," Mr. J. S. Keltie dealt with the subject of commercial geography, the importance of which it was long left to the Society of Arts to urge, but which, it is satisfactory to see, is now attracting its due amount of public attention.

M. Talbot Reed's paper on "Old and New Fashions in Typography" contained many original ideas, and had an important bearing not only on the artistic portion of the subject, but on a question which has not yet received the attention it deserves—that of the choice of the best type as regards its effect on the sight of readers. The chance of finding coal in workable quantities in the south-east of England was discussed in an excellent paper by Mr. Whitaker. Mr. Whitaker stated very clearly the reasons for expecting to find coal in sufficient quantities to make it worth working, and was clearly of opinion that further search for coal would be well directed. Dr. Fleming, in his account of "Prof. Elihu Thomson's Electro-Magnetic Induction Experiments," succeeded in making a very difficult subject extremely clear, and showed once more how the progress of pure science is interwoven with applied science, since it is only by the advances which have been made in the construction of large and powerful machinery for electric lighting that experiments such as those he showed to the audience could even have been attempted.

At the last meeting of the Session, Mr. J. G. Gordon brought before the Society an account of the remarkable process for making seamless tubes, invented and patented by the Messrs. Mannesmann. In this process a tube is rolled out of a solid bar direct by the action of a pair of conical rollers between which it is passed. The precise *rationale* of the process does not seem to be entirely understood by anyone, but it appears certain that tubes of greater strength are obtained by this process than by any other, on accout of the fibres of the metal being arranged more or less helically round the tube.

From the above summary it will be seen that the papers which the Society has had before it during the Session now concluded are, as a whole, inferior neither in interest nor in practical and scientific value to those read in any previous year.

II.—INDIAN SECTION.

The opening meeting of the Indian Section was held on the 17th of January, when Mr. Frederic C. Danvers gave an exceedingly interesting description of the valuable manuscript and other records at the India-office, and of his work in classifying and describing them during the last six years. The paper was of historical value, as throwing light on the growth of the East India Company, and attracted a great deal of attention. On the 7th of February, Dr. Schlich, at the second meeting of the Section, contributed a paper on "The Utility of Forests, and the Study of Forestry." The learned professor at Cooper's Hill showed how necessary a scientific training was to those officers who undertook the charge of the immense and invaluable forests which are the property of the Government of India. General Michael, who more than forty years ago was entrusted with the control of the earliest experimental operations in forestry in Madras, presided, and was able to supply from his own experience much interesting information about the infancy of one of the great administrative and revenue-producing departments of the Indian Government. An opinion that found very general expression in the course of the discussion was that the Indian Government should expend a larger portion of the revenue derived from this department in improving the forests of India. On the 28th of February, the third paper of the Section was read by Mr. William Sherriff, of Rangoon, and the subject chosen was "The Northern Shan States and the Burma-China Railway." Mr. Sherriff gave a very graphic account of a journey he took with one of our first surveying columns through the Shan States, and Sir Charles Bernard, who presided, bore personal testimony, from his experience as ruler of Upper Burmah, to the soundness of Mr. Sherriff's conclusions, and the reasonableness of his expectations about the development of trade in the Shan States. The fourth paper of the Session was read on the 14th March, by Mr. W. R. Robertson, on "Agriculture in India," a subject with which he is thoroughly acquainted. The paper may be regarded as a continuation and completion, as it were, of the three papers which Mr. Robertson had given on similar subjects before the Section in previous Sessions. On the 8th May, Mr. Demetrius Boulger read a paper on "The Western Frontiers of China," a subject of great and growing importance. At the sixth and last meeting of the Session, a very interesting and important paper on "The Rationale of Indian Railways," was read on the 12th June, by Sir Theodore C. Hope, late Member of the Viceroy's Council. The paper gave a very full and comprehensive account of the Indian railway system, and the manner of its development from its origin down to the present time. The Marquis of Ripon, K.G., who was Viceroy during the first part of Sir Theodore's administration of railways and other public works, presided on the occasion.

Two changes have to be noted with regard to the meetings of the Section during the present Session. The first is the alteration of the hour of meeting from eight in the evening to five in the afternoon, and the second, necessitated by the first, the change of the day of meeting from Friday to Thursday.

III.—FOREIGN AND COLONIAL SECTION.

In this Section, as in the Indian, the time of meeting was changed from eight to five, it having been thought by the Council that afternoon meetings would be more convenient to many of the members than meetings in the evening, especially now that the latter are so numerous.

Six papers have as usual been read in this Section during the past Session. On the 21st January, Mr. J. L. Shand described "The Tea, Coffee, and Cocoa Industries of Ceylon," in an interesting and practical paper. On February 18th, a paper was read by Mr. J. Henniker Heaton, M.P., on "Ocean Penny Postage and Cheap Telegraph Communication between England and all parts of the Empire and America." It is interesting to note that since the reading of this paper the Chancellor of the Exchequer has conceded the principle of a 2½d. postage rate for India and the Colonies. On March 18th, Mr. James W. Wells, M.Inst.C.E., read a paper upon Brazil. The reader gave an interesting account of the resources of that country, and of the causes which led to the recent revolution. On April 22nd, Lieut.-General Sir John Stokes, K.C.B., described the works which have been carried out, with Sir Charles Hartley as engineer, by a European Commission, for the improvement of navigation on the Danube, and gave a very valuable account of the difficulties, both natural and political, which attended the commencement of these works and of the success ultimately achieved. A paper was read on the 15th May, by Mr. Washington Eves, C.M.G., on Jamaica, and the Exhibition about to be held there, and explained the advantages likely to arise both to the island and to exhibitors thereby. The concluding paper of the Session was "The Industrial Arts of Japan," by Mr. A. Lasenby Liberty, on May 20th, and was fully illustrated by a fine collection of specimens, the result of Mr. Liberty's recent visit to the island.

IV.—Applied Art Section.

Mr. E. C. Robins read a paper on "The Relation of the Fine Arts to the Applied Arts" at the opening meeting of this Section on the 18th January, in which he advocated combined action in respect to the improvement of facilities for the higher art education. In the discussion which followed the reading of the paper, some objection was taken to the generally received distinction between the fine and applied arts. At the second meeting, on the 11th February, a paper on "Cast Iron and its Treatment for Artistic Purposes" was read by Mr. W. R. Lethaby, who pleaded for the just claims of a somewhat despised art, and showed how truly artistic were many of the old specimens in which the limits of the use of the material were honestly accepted. Mr. James Orrock advocated, in a paper read on the 11th March, "The Claims of the British School of Painting to a thorough representation in the National Gallery," and he supported his contention by the exhibition of a collection of beautiful oil and water-colour paintings by illustrious English masters whose works are either not included in the National Gallery or are inadequately represented there. This fine exhibition was kept open in the meeting-room for a few days after the meeting. There seems some probability that Mr. Orrock's paper may lead to the formation of the Gallery of National Art, so earnestly in past years advocated by this Society. Mr. W. J. Linton, whose valuable Cantor Lectures on "Wood Engraving" delivered last Session were highly appreciated by the members, read a paper on 25th of March on "Engraving in Wood, Old and New," in which he dealt very fully with what is known as "the new departure" in wood-engraving, and strongly condemned it. Mr. C. Purdon Clarke treated the subject of "Modern Indian Art" in a paper on the 15th April, and pointed out how the ornamental handicrafts of India were being gradually destroyed. He urged that in order to preserve the industrial arts of India, the old workshop traditions must be cherished. The Session was brought to a close with Professor Roberts-Austen's paper on the "Use of Alloys in Art Metal Work," in which were shown the marvellous effects obtained by the Japanese by their use of alloys, and the hope was expressed that English artists would adopt methods which would so greatly add to the possibilities of their arts.

V.—Cantor Lectures.

During the past Session there have been five courses of Cantor Lectures. The first of these, given before Christmas, was by Mr. Jago, on "Modern Developments of Bread Making." Mr. Jago gave a very full account of the numerous improvements—principally, of course, mechanical—which of recent years have been introduced into this, perhaps, most important of all industries. By his course of four lectures on "The Electro-magnet," Prof. Silvanus Thompson added one more to the admirable courses of lectures on electrical subjects by which he has made the Society of Arts his debtor. Mr. Bolas, in his three lectures on "Stereotyping," dealt with a thoroughly practical subject in a thoroughly practical manner, working actually before his audience all, or nearly all, the processes which he described. Prof. Church, in his lectures on "Colour and Colouring," dealt with another side of a subject one portion of which was treated last year by Captain Abney. Mr. Richard Bannister concluded the series of Cantor Lectures for the Session with a course of four lectures on "Sugar, Tea, Coffee, and Cocoa." These were all fully illustrated, and were at once very interesting and full of important information.

VI.—Juvenile Lectures.

The Juvenile Lectures this year were given by Professor Vivian Lewes, his subject being the "History of a Flame." The lectures, as usual, were of a thoroughly simple and popular character and abundantly illustrated with experiments. The admirably lucid and intelligible manner in which a great deal of valuable information was conveyed by Mr. Lewes was thoroughly appreciated by his youthful audience.

VII.—ADDITIONAL LECTURES.

In addition to the usual courses of Cantor Lectures, a special course of lectures was given by Mr. Lewis F. Day, on "Design Applied to Wood-carving." These lectures arose out of an application made to the Council of the Society by the executive of the School of Wood-carving at South Kensington, the students of which have often felt the want of instruction in the principles applicable to their art. Mr. Day's lectures were, therefore, specially intended for practical students of wood-carving, a large number of whom attended them.

VIII.—POPULAR LECTURES.

In previous Sessions much satisfaction has been given to the Members by courses of lectures of a popular character, dealing with some subject of a scientific nature. Such, for instance, was the course by Professor George Forbes on "Electricity," given in 1886. The Council thought that a similar course during the present year would be very acceptable, and they have every reason to believe that the lectures which, in response to their request, Professor Lewes gave on "The Atmosphere" were well appreciated by a large body of the Members. They were given on four Saturday afternoons in March.

IX.—ALBERT MEDAL.

The Albert Medal has been awarded for the present year to Mr. W. H. Perkin, F.R.S., for his discovery of the method of obtaining colouring matter from coal tar, a discovery which led to the establishment of a new and important industry, and to the utilisation of large quantities of a previously worthless material.

Mr. W. H. Perkin was the first not merely to produce a beautiful colour from the then utterly valueless bye-product, coal tar, but was also the first to prepare it upon a manufacturing scale and to apply it to dyeing purposes. The discovery and manufacture of mauve by him in 1856 laid the foundation to a new branch of industry—the coal tar colour industry—which within a few years revolutionised dyeing, and exercised in a brief period a most important influence upon the arts, and upon all manufactures in which dyes were concerned. In his official report upon the Chemical Section of the Exhibition of 1862, Professor Hofmann said:—"To a young English chemist, Mr. W. H. Perkin, is due the honour of having first elicited the industrial value of coal tar . . . . and of first separating the purple colouring matter capable of being fixed as a dye upon fabrics. The complete success of the industrial applications of aniline, and the extraordinary revolution thereby occasioned in the different branches of dyeing, are strikingly illustrated by the Industrial Exhibition of 1862." Mr. Perkin's first successes were followed by the discovery of a series of magnificent dyes, and eventually he—coincidently with two German chemists—not only produced the colouring principle of the madder root (Turkey red) artificially, but he was also the first to elaborate a thoroughly successful process of manufacture of this important colouring matter from a product of the distilation of gas tar. It may fairly be said that no chemist or manufacturer has exercised a more important beneficial influence upon the recent progress of arts, manufactures, and commerce than Mr. W. H. Perkin. For his scientific labours he has received the highest honours which the Royal Society can bestow.

X.—AWARD OF MEDALS FOR PAPERS.

In accordance with long-standing custom, the Council have awarded Society of Arts' silver medals to the readers of some of the more important papers read during the Session. These are—

At the Ordinary Meetings:—

To ARMAND RUFFER, M.A., M.D., for his paper on "Rabies and its Prevention."

To ARTHUR PAGET, for his paper on "High Speed Knitting and Weaving without Weft."

To TALBOT B. REED, for his paper on "Old and New Fashions in Typography."

To WILLIAM WHITAKER, F.R.S., for his paper on "Coal in the South-East of England."

To Dr. J. A. FLEMING, for his paper on "Prof. Elihu Thomson's Electro-Magnetic Induction Experiments."

To J. G. GORDON, for his paper on "The Mannesmann Process for making Seamless Tubes."

In the Foreign and Colonial Section:—

To Lieut.-General Sir JOHN STOKES, K.C.B., for his paper on "The Danube and its Trade."

To A. LASENBY LIBERTY, for his paper on "The Industrial Arts of Japan."

In the Indian Section:—

To FREDERICK C. DANVERS, for his paper on "The Records of the India-office."

To Sir THEODORE C. HOPE, K.C.S.I., C.I.E., for his paper on "The Rationale of Indian Railways."

In the Applied Art Section :—

To JAMES ORROCK, R.I., for his paper on "The claims of the British School of Painting to a thorough representation in the National Gallery."

To Prof. W. C. ROBERTS-AUSTEN, C.B., F.R.S., for his paper on "The Use of Alloys in Art Metalwork."

The Council have also voted their thanks to the following members of their own body, and to the Secretary, for the papers which they had read, as they have always considered themselves precluded from awarding medals in such cases :—

To Sir ROBERT RAWLINSON, K.C.B., for his paper on "London Sewerage and Sewage."

To R. BRUDENELL CARTER, F.R.C.S., for his paper on "Practical Vision Testing."

To Sir DOUGLAS GALTON, K.C.B., D.C.L., F.R.S., for his paper on "The Chemin de Fer Glissant, or Sliding Railway."

To EDWARD C. ROBINS, F.S.A., for his paper on "The Relation of the Fine Arts to the Applied Arts."

To H. TRUEMAN WOOD, M.A., Secretary to the Society, for his paper on "The Paris Exhibition."

XI.—PRIZES FOR ART-WORKMANSHIP.

It was stated in last year's report that the Council had determined to modify the system under which prizes are offered for Art-workmanship, and to offer prizes in connection with the Exhibition of the Arts and Crafts Society, which was announced for holding last autumn. Accordingly the sum of £150 in money, and twenty of the Society of Arts bronze medals, were offered for objects in the Exhibition, the rules under which the prizes were offered being substantially the same as those under which previous Art-workmanship competitions were held. Prizes to the amount of £128 were awarded by judges appointed by the Council, as well as fifteen medals. The classes of work for which prizes were given included metal work, pottery, enamels, glass, jewellery, gesso, wood-carving and cabinet-work, book-binding, textiles, lace, and designs. A list of the awards appeared in the *Journal* in October last.* The question of renewing the offer in connection with the next Exhibition of Arts and Crafts was very carefully considered by the Council, and negociations were for a long time carried on between it and the Committee of the Arts and Craft Society, but it was not found possible to agree on a satisfactory manner of conjoint working by which the objects of the two Societies should be attained, and the proposal to offer prizes for Art-Workmanship was therefore—not without considerable regret on the part of the Council—abandoned.

XII.—OWEN JONES PRIZES.

These prizes have been awarded annually since 1879 on the results of the annual competition of the Science and Art Department to students of the Schools of Art, who produce the best designs for household furniture, &c., on the principles laid down by Owen Jones. As usual, six prizes were offered for competition last year, each prize consisting of a bound copy of Owen Jones's "Principles of Design" and a Bronze Medal. A list of the successful candidates has appeared in the *Journal*.* A similar number of prizes has been offered for the present year (1890), and the result of the competition will be published in the *Journal* as soon as it is received from the Science and Art Department.

XIII.—PRIZES FOR DRAWING.

In response to an application from the recently established Drawing Society, which was the outcome of the paper read before the Society by Mr. T. R. Ablett, in 1888, the Council offered twelve bronze medals for the competition in schools established by the Drawing Society. Of these, seven were awarded. The object of the society is to promote the teaching of drawing in schools. Its first exhibition was held in April last, and it is proposed to continue similar exhibitions annually.

XIV.—EXAMINATIONS.

It is very satisfactory to be able to record a large increase in the number of candidates for the General Examinations, though the proposed examinations in practical commercial knowledge have again failed to attract, and will—since it is evident that there is, at all events, at present, no demand for them—be discontinued. The number of papers worked at this year's examinations was 2,474, an increase of over 33 per cent. on last year's total, 1,861. There has been a steady rise in numbers since 1886, when the number, 1,273, was little more than half the present total. It may fairly be assumed, from this regular and considerable increase, that the Society's examinations, to a large extent, meet the want which has been of late so loudly expressed for an examination in the principal subjects of a commercial examination.

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* See *Journal*, October 11, 1889, vol. xxxvii., p. 851.

* See *Journal*, August 9th, 1889, vol. xxxvii., p. 735.

The increase is distributed over nearly all the subjects. It shows most in Book-keeping, in which 1,008 candidates were examined, the number last year being 782. The next largest subject is Shorthand, 554, compared with 203 in 1889. For the Theory of Music there were 230, last year 203. Next comes Arithmetic, 180, against 138; next French, with 153, the number in 1889 being 134. In English there were 115, an increase on the 80 of last year, but, curiously enough, in this important subject, there is an actual falling off, as compared with the numbers in some former years, as 1885, when there were 118 out of a total of 1,315. In German there is a small increase, 80 against 66. Spanish has 55 against 30. In the other modern languages the numbers are very small:—Portuguese 7 (4 in 1889), Danish 3 (1 last year), Italian 3 (less than last year when there were 5). In Russian, Chinese, and Japanese there were no candidates. For Domestic Economy there were 66, compared with 48 last year. For Political Economy there were only 7, less than last year when there were 12. Commercial Geography only attracted 13 candidates, last year there were 11.

With so large an increase in numbers it is not to be wondered at if the average standard of the candidates has slightly fallen. This is certainly the case. In Book-keeping, where the increase has been most remarkable, the per-centage of first-class certificates has fallen from 19·8 per cent. last year (an unusually high per-centage) to 11·5, showing very distinctly that the increase has been in the lower stages. In Shorthand the per-centage of first-class is very nearly the same as last year, but the proportion of seconds is much higher. In Arithmetic the candidates did not do well; the attention of teachers of classes should be given to the remarks of the examiner, which will be printed with the programme for next year. In modern languages generally the results are reported as satisfactory in quality as well as quantity. In English the answers of the candidates leave a good deal to be desired. In the Theory of Music the standard appears to have been kept up. In Political Economy the candidates showed a want of instruction which, now that so many means exist of obtaining it, should not be the case. The report on the Domestic Economy papers is on the whole good. In Commercial Geography there is improvement, but the numbers are still insignificant.

The Council propose next year to offer a medal or medals in each subject, and possibly other prizes, in the hope of attracting more candidates of the better class. Particulars of the offer will be given in the examination programme shortly to be issued.

XV.—PRACTICAL MUSICAL EXAMINATIONS.

In the hope of raising the standard of the candidates in their examinations, the Council decided to offer a Society's Bronze Medal to any candidate who should obtain the maximum number of marks, and a Society's Silver Medal to any candidate taking a first-class certificate in honours who should show sufficient merit. This offer certainly had the desired effect of attracting a better class of candidates, and induced some who had in former examinations obtained full marks to present themselves for further tests. This accounts for the awards being somewhat more numerous than had been anticipated.

The examinations were held in London this month. There were 305 candidates, 266 of whom passed the examination, taking 286 certificates—111 first class, and 175 second class. Eighteen candidates obtained full marks, and will therefore receive bronze medals. Two of the candidates also took first class honours. The working of the papers for honours showed an improvement on former years, but none were of a sufficiently high standard to justify the award of the Silver Medal. It should be stated that many of the candidates were examined in vocal as well as in instrumental music, and consequently the number of certificates awarded does not agree with the total number of candidates passing. On the whole, the standard of former years has been kept up. Better preparation for the reading test has been made in many instances, and the value of the ear test has been duly recognised. There was a considerable increase in the number of candidates, as compared with those of last year, when 225 candidates presented themselves. The number examined in 1888 was 259; in 1887, 188.

XVI.—MEMORIAL TABLETS.

Since the last announcement in connection with this subject, which was in the Report for 1886-7* a memorial tablet has been placed

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* A list of the houses on which tablets have been placed was given in the *Journal* for July 2nd, 1886, p. 861. Since that date a tablet has also been set up to Thackeray (see *Journal*, July 1st, 1887, p. 782).

(by permission of the Benchers of Lincoln's-inn) to mark the residence of John Thurloe, Secretary of State to Oliver Cromwell, in the ground floor of No. 24, Old-square. The tablet has been placed on the Chancery-lane front of the building. A tablet in commemoration of the residence of Robert Browning, at No. 19, Warwick-crescent, Paddington, from 1861 to 1887, has been prepared, and is about to be placed on the front of the house.

XVII.—CONVERSAZIONE.

The Conversazione for last year was held, as in many previous years, at the South Kensington Museum. For the present year, the Society have been favoured by the Trustees of the British Museum with permission to hold the conversazione in the Natural History Museum at South Kensington. The Council feel that the Society are much indebted to the Trustees for this privilege. The principal difficulty which stood in the way arose from the fact that the Museum buildings are not lighted at night. Gas-pipes have been laid on in the Central Hall, but in other parts of the building no provision for artificial lighting at all is made. This difficulty was got over by arrangement between the Society and the Royal Colonial Institute, under which the cost of putting up temporary fittings was divided between the two bodies, certain other necessary expenses being dealt with in the same manner. The arrangements it is proposed to adopt have already been announced in the *Journal*, and it is expected that the additional expenses will to a large extent be met by the receipts from the sale of extra tickets to the members. The Council have to acknowledge the kind assistance they have received in carrying out the arrangements from Professor Flower, the Director of the Museum, and from Mr. Fagan, the Secretary.

XVIII.—JAMAICA EXHIBITION.

A London Committee having been formed to assist in the organisation of an Exhibition in Jamaica, and an application having been made to the Council to nominate one of their number as a member of the Committee, they had much pleasure in asking Mr. C. M. Kennedy to serve in that capacity. The arrangements for the Exhibition were detailed in a paper read near the end of the Session by Mr. Washington Eves, and there seems every prospect of a successful Exhibition, and one likely to be of service to the Colony.

XIX.—IMPERIAL INSTITUTE.

A notification has been received by the Council that the Society will be invited to nominate a representative on the Governing Body of the Imperial Institute. The constitution of the Governing Body has recently been published, but no steps have as yet been taken to call it into existence.

XX.—DAVENPORT FUND.

It may be in the recollection of some of the members that on the death, in 1876, of Mr Samuel Davenport, who had been for many years the Financial Officer of the Society, a subscription for his family was set on foot among the members of the Society. An amount of £1,588 was thus obtained, the greater part of which, £1,500, was invested. The interest on this amount was paid over to Mrs. Davenport, and after her death was applied for the benefit of the children. The youngest member of the family having now come of age, the bonds of the Mersey Dock and Harbour Board, in which the money was invested, have been sold, and the amount realised equally divided amongst the surviving children of the late Mr. Davenport,

XXI.—NEW COUNCIL.

In accordance with the Bye-laws, the Council have prepared the usual balloting-list for the election of the new governing body of the Society. During the year the Duke of Manchester, a Vice-President of the Society, died, and there are also four Vice-Presidents who retire in accordance with the usual rules. These are Sir Frederick Abel, Sir Frederick Bramwell, Major-General Donnelly, and Sir Polydore De Keyser. To fill the five vacancies, the Council propose for election Sir Edward Birkbeck, Professor James Dewar, Sir Henry Ponsonby, Mr. Cobb, who retires in rotation from the office of Treasurer, and Sir Henry Doulton, whose term of service as an ordinary member of Council has expired. In addition to Sir Henry Doulton, three other members of Council are obliged to retire, Sir Benjamin Baker, Sir Juland Danvers, and Lord Sudeley. In their place the Council propose Sir George Hayter Chubb, Mr. James Dredge, Mr. J. F. Moulton, and Major-General Michael. None of these gentlemen have served on the Council before. To fill Mr. Cobb's place as Treasurer, the Council are glad to be able to put forward Sir Frederick Bramwell, whose services to the Society have been so many and so great.

XXII.—THE SECRETARY.

The Council are glad to be able to congratulate members of the Society on the circumstance that her Majesty has been graciously pleased to confer the honour of knighthood on Mr. Henry Trueman Wood, who has filled the office of Secretary to the Society since the death of the late Mr. Le Neve Foster, in 1879. They feel sure that the members will be gratified at this public acknowledgment of Mr. Wood's valuable services to the Society and the important national interests which it represents.

XXIII.—LIST OF MEMBERS.

The total number of life members, subscribing members, and institutions in union which subscribe to the Society from their own funds, is now 3,362. During the year 1889-90, 304 members have been removed from the list by death or resignation. During the same period 260 have been elected.

XXIV.—OBITUARY.

The Society has not so many losses by death to deplore as in some recent years. During the year just ended, however, two recipients of the Albert Medal have passed away, Dr. Joule and Dr. Percy, the latter, as will be remembered, having only lived just long enough to receive the news of the compliment the Society had paid him. The Duke of Manchester was a Vice-President of the Society at the time of his death. Mr. J. G. Crace and Mr. Newton were in years gone by closely associated with the Society's work. Mr. Thomas Gray, of the Board of Trade, took a more recent share in it, as did also Mr. Westgarth, whose liberal offer of prizes for essays on London improvement will be in the recollection of members. The Rev. Father Perry, whose death was so great a loss to astronomical science, was a member of the Society, as was Sir E. Baines, the veteran journalist. M. Buys-Ballot, the distinguished Dutch meteorologist, was an honorary member, and had been recommended for the Albert Medal by the Royal Academy of Science of Amsterdam, as well as by our own Meteorological Society. Sir James Marshall, who rendered distinguished services in Western Africa, joined the Society at the time of the Colonial Exhibition. Mr. Adamson, one of the original promoters of the Manchester Ship Canal, was an old member of the Society. Notices of the above, and of some other members who died during the past twelve months, have appeared in the columns of the *Journal.*

XXV.—FINANCE.

In accordance with the Bye-laws, a statement showing the receipts, payments, and expenditure, for the year ending May 31st last, was published in the last number of the *Journal.* The financial condition of the Society has not greatly altered during the past two or three years, and there does not appear to be anything in the statement calling for special explanation or remark. That the financial position of the Society is thoroughly satisfactory is shown by the fact that the assets amounted on the 31st May to £17,775, while the actual liabilities of the Society were only £1,255.

The CHAIRMAN moved the adoption of the Report, the motion being seconded by Mr. COBB, and carried unanimously.

Mr. WALTER SMARTT referred to the slight decrease in the number of members, and thought it was a mistake to make the charge for life composition the same in all cases, without regard to the age of a member or the number of annual subscriptions paid. He also thought the charges on account of the *Journal* were very heavy, and that if this cost could be lessened, together with its selling price, its circulation might be increased, as well as its value as a medium for advertisements. With regard to the Society's investments, he thought the amount of Consols held too large, considering the smallness of their dividends, and recommended an increased investment in ground-rents.

Mr. MARTIN WOOD, alluding to the Society's examinations, said he considered the number of candidates was still small, taking into account the large area covered by the system, and that more efforts should be made to popularise the examinations throughout the provinces. With regard to the Popular Lectures, which had late formed part of the Society's programme, he should like to know whether the attendance at them had been satisfactory, in which case he suggested they should be multiplied, as a means of helping to keep up the number of members.

Lord ALFRED CHURCHILL urged that every member should do his best to bring in new members, in order to maintain and increase the prosperity of the Society.

The SECRETARY, replying to the remarks of Mr. Smartt as to the cost of printing the *Journal*, stated that the lowest tender for printing had been accepted when the arrangement was first made. By paying ready money, the Society obtained the benefit of specially low terms. A proportion of the total cost was on account of the postage to members and others, the *Journal* being widely distributed not only within this country but all over the world. With regard to the Society's examinations, the Committee adopted all means in their power for making them widely known, but the Council would always welcome any suggestions in this direction. The Popular Lectures had been well attended, and he believed were liked by the members.

The ballot having remained open for one hour, and the Scrutineers having reported, the CHAIRMAN declared that the following had been elected to fill the several offices. The names in *italics* are those of members who have not, during the past year, filled the office to which they have been elected.

PRESIDENT.

H.R.H. the Prince of Wales, K.G.

VICE-PRESIDENTS.

H.R.H. the Duke of Edinburgh, K.G.
H.R.H. the Duke of Clarence and Avondale, K.G.
The Duke of Abercorn, C.B.
William Anderson, M.Inst.C.E.
The Attorney-General, M.P.
Sir Francis Dillon Bell, K.C.M.G., C.B.
Sir Edward Birkbeck, Bart., M.P.
Major-General Sir Owen Tudor Burne, K.C.S.I., C.I.E.
Alfred Carpmael.
R. Brudenell Carter, F.R.C.S.
Lord Alfred S. Churchill.
B. Francis Cobb.
Sir Daniel Cooper, Bart., G.C.M.G.
Sir Philip Cunliffe-Owen, K.C.B., K.C.M.G., C.I.E.
Professor James Dewar, M.A., F.R.S.
Sir Henry Doulton.
James Staats Forbes.
Sir Douglas Galton. K.C.B., D.C.L., F.R.S,
Thos. Hawkesley, F.R.S.
Sir Villiers Lister, K.C.M.G.
General the Right Hon. Sir Henry F. Ponsonby, G.C.B.
Sir Robert Rawlinson, K.C.B.
Lord Thurlow, F.R.S.

ORDINARY MEMBERS OF COUNCIL.

Sir George Birdwood, K.C.I.E., C.S.I., M.D., LL.D.
Michael Carteighe.
Sir George Hayter Chubb.
James Dredge.
Alex. B. W. Kennedy, F.R.S.
Chas. Malcolm Kennedy, C.B.
John Biddulph Martin.
George Matthey, F.R.S.
Major-General Michael, C.S.I.
John Fletcher Moulton, Q.C., F.R.S.
William Henry Preece, F.R.S.
Edward C. Robins, F.S.A.

TREASURERS.

Sir Frederick Bramwell, Bart., D.C.L., F.R.S.
Sir Owen Roberts, M.A., F.S.A.

SECRETARY.

H. Trueman Wood, M.A.

The CHAIRMAN moved a vote of thanks to the Scrutineers, which was carried unanimously.

Sir FREDERICK BRAMWELL proposed the best thanks of the meeting to the Duke of Abercorn for his valuable services to the Society as Chairman of its Council during the past two years.

The CHAIRMAN briefly responded.

Miscellaneous.

NATIONAL GALLERY OF BRITISH ART.

The proposal to form a National Gallery of British Art, which was advocated by the Society of Arts in 1847, and was again brought before the Society by Mr. James Orrock in a paper read on March 11th last, is now before the public in the practical form ot an offer by Mr. Henry Tate of 57 pictures by British artists to form such a gallery. Mr. Tate's letter to the Chancellor of the Exchequer, with a list of the pictures, and the "Draft of a proposal to the Lords of her Majesty's Treasury for the establishment of a National Gallery of British Art under a distinctly separate administration from that of any existing institution," is printed in the *Times* of Saturday, 21st inst. Mr. Tate's letter is as follows:—

To the Right Honourable G. J. Goschen, M.P., Chancellor of the Exchequer, &c.

SIR,—The offer of my pictures to the National Gallery having been declined for want of space, many of the suggestions which have been made from time to time respecting the establishment of a national gallery exclusively confined to works by British artists lead me to the consideration of the special and particular lines on which such an institution should be founded, and the functions it should be established to perform, whether the work is to be effected by Government or by private action and enterprise, or by a judicious combination of both.

If the Lords of the Treasury, acting for the Government, sanction the establishment of such an institution on the lines indicated and laid down in the schedule attached, and the Lords of the Treasury agree to render reasonable pecuniary assistance by means of annual grants for the purpose of enabling the administration to assist provincial museums by loans of paintings, water-colours, drawings, sculptures, &c., on a system similar to that adopted with so much usefulness and success with objects of industrial and decorative art by the circulation department of the South Kensington Museum, or if the Government will grant sufficient aid for the maintenance of the gallery and its administration alone, leaving to the future the sending of some portion of the collections on loan to provincial museums :—

Upon these conditions I am prepared to present to the nation a selection of pictures out of my collection as specified in the annexed list, numbering 57, and further to allow the committee of selection to take any of the others which I possess, and which they may think it desirable to have included in my gift.

It is, however, to be understood that I will only consent to allow these pictures to be taken out of my possession when a suitable and separate gallery shall have been erected, or an existing one prepared for their reception, the structure and situation of which shall have previously met with my approval, and the Lords of the Treasury having undertaken to complete the same at the latest by June 30, 1892.

I have the honour to be, Sir, your obedient servant, HENRY TATE.

Park-hill, Streatham-common, S.W.,
June 17th.

Correspondence.

USE OF ALLOYS IN ART METAL-WORK.

MR. LASCELLES-SCOTT writes:—I have read with peculiar satisfaction and interest that part of Prof. Roberts-Austen's paper which deals with the Japanese methods of dealing with laminated alloys for art purposes, since many years ago I was indebted to the late Mr. George for some specimens of this variety of the native handicraft.

I was greatly struck with the beauty and ingenuity displayed in some of these specimens, consisting of a perfectly flat (polished or finely grained) surface, in which were drawn or damascened designs in various tints and shades. Only by cutting (*i.e.*, making transverse sections of), say, a paper-knife, did I get a notion of how the effect was produced, viz., by superimposing laminæ of differently coloured alloys, indenting the compound strip from one side, and filing or grinding down the other surface.

Interested at that period in metallic alloys, I endeavoured—not quite unsuccessfully—to imitate the effect of the Japanese specimens, by having layers of copper, gun-metal, &c., with and without arsenic, and antimony, rolled into a compound ribbon. The latter was stamped, from one side, with the impression of strongly-veined leaves and other objects (from hardened electrotype *fac-similes*), and the relief side being then ground flat, a kind of shaded drawing of the object or design resulted. Believing that the electrotype process might be utilised at other stages of the work, I placed the entire matter in the hands of a friend (my own attention being needed elsewhere), whose early death prevented my hearing anything more upon the subject.

Systematically worked out, I am convinced that there would be a great future for work of this metallic *chiar-oscuro* kind, if I might express myself, and I feel grateful, therefore, to Prof. Roberts-Austen for having introduced the subject to the notice of the Society.

General Notes.

FRENCH WINES.—The production of wine in France last year was 23,223,600 hectolitres (of 22 gallons), being a diminution of 6,878,500 hectolitres on the previous year, and nearly that amount on the average production of the ten previous years. This decline is attributed not only to the phylloxera, but also to other parasitical attacks on the vine, such as mildew, and black rot, and the humid temperature of the spring. The deficiency in the production was made up by purchases from other countries of 6,372,000 hectolitres, of which 1,346,000 were from Algeria, 820,000 from Portugal, and 92,000 from Italy. Made wines were also produced to the extent 3,305,000 hectolitres from the marc, with sugar added, and 1,826,000 from raisins. The land under vines is returned at 1,817,787 hectares. The comparative total yield of wine was, for 1888, 30,102,151 hectolitres; for 1889, 23,223,572 hectolitres. The culture of the vine in Algeria continues to increase. There are 94,842 hectares under vines in the three provinces, and the yield of wine was 2,512,198 hectolitres, which is a few hundred hectolitres below the previous year's production, arising from the permanence of the sirocco in July, and the intense dryness which resulted therefrom. The production of cider in France last year was but 3,701,342 hectolitres, a decline of 6,000,000 hectolitres compared with the previous year, and nearly 9,000,000 hectolitres below the average of the previous ten years. This decrease is attributed to the excessive rains and late frosts in the spring, which were more detrimental to the apple-trees than they were to the vines.

CLOVE CULTURE.—The clove tree was introduced into Zanzibar about the year 1830, and its cultivation now forms the chief industry of the islands of Zanzibar and Pemba. The chief supply of cloves is obtained from these islands. Consul Pratt, who has lately written a report on the clove culture of Zanzibar, says that a ten-year old plantation should produce an average of 20 lbs. of cloves to a tree. Trees of twenty years frequently produce upwards of 100 lbs. each. Mr. Pratt reports that the yield of the present season will probably exceed that of any previous season, and amount to 13,000,000 lbs., averaging a local value of 10 cents per pound.

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FRIDAY, JULY 4, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

CHAIRMANSHIP OF COUNCIL.

On Tuesday last, 1st inst., at their first meeting after the annual election, the Council elected Sir Richard Webster, M.P., Attorney-General, as Chairman of Council, and Sir Frederick Bramwell, Bart., D C.L., F.R.S., as Deputy-Chairman for the ensuing year. The various Committees were also re-appointed.

Proceedings of the Society.

CONVERSAZIONE.

The Society's Annual *Conversazione* was held at the Natural History Museum, Cromwell-road (by permission of the Trustees of the British Museum), on Friday evening last, 27th ult.

The following portions of the Museum were open: On the ground-floor—the Central Hall, British Saloon, Bird Gallery, and a portion of the Gallery of Fossil Mammalia. On the first-floor—the East and West Corridors and the Lecture-room (for refreshments).

The Reception was held in the Central Hall, by the Duke of Abercorn, C.B., Chairman, accompanied by the Duchess of Abercorn, and the following Vice-Presidents and Members of Council:—Sir Frederick Abel, C.B., D.C.L., F.R.S., Sir Frederick Bramwell, Bart., D.C.L., F.R.S., Mr. William Anderson, Sir Benjamin Baker, Major General Sir Owen Tudor Burne, K.C.S.I., Mr. Alfred Carpmael, Mr. B. Francis Cobb, Sir Juland Danvers, Major-General Donnelly, C.B., Mr. J. Biddulph Martin, Mr. George Matthey, F.R.S., Mr. W. H. Preece, F.R.S., Sir Robert Rawlinson, K.C.B., Mr. Edward C. Robins.

Promenade concerts were given by the Band of the Grenadier Guards (Conductor, Lieut. Dan Godfrey) in the Central Hall, and by the Band of H.M. Scots Guards (Conductor, Mr. Edward Holland) in the Bird Gallery.

BAND OF THE GRENADIER GUARDS.

1.	Grand March	"Souvenir de Biarritz"	Bilemma.
2.	Overture	"Morning, Noon and Night"	Suppé.
3.	Selection	"Lohengrin"	Wagner.
4.	Valse	"Ange d'Amour"	Waldteufel.
5.	Idyll	"Ein Blümchen der Einsamkeit"	E. Bach.
	Intermezzo	"Loin du Bal"	Gillett.
6.	Selection	‘The Gondoliers"	Sullivan.
7.	Overture	"Tantalusqualen"	Suppé.
8.	Cornet Solo	"In the Starlight"	D. Godfrey, Jun.
		Sergeant Knight.	
9.	Valse	"Tout-Paris"	Waldteufel.
10.	Incidental Music to	"King Henry VIII."	Sullivan.
11.	Selection	"Faust up to Date"	Meyer Lutz.
12.	Suite Espagnole		Désormes.
13.	Marche Militaire		Gounod.

God Save the Queen.

BAND OF H.M. SCOTS GUARDS.

1.	March	"Neujahrs-gruss"	Carl.
2.	Overture	"Die Irrfahrt um's Glück"	Suppé.
3.	Valse	"Christmas Roses"	Waldteufel.
4.	Selection	"Les Huguenots"	Meyerbeer.
5.	Polonaise		Chopin.
6.	Selection	"Lieder ohne Worte"	Mendelssohn.
7.	Gavotte	"J'y Pense"	Eilenberg.
8.	Polka	"Una"	Hartman.
		(Solo Cornet) Musician W. Drake.	
9.	Overture	"Oberon"	Weber.
10.	Allegretto Scherzando from 8th Symphony		Beethoven.
11.	Divertissement	"Lohengrin"	Wagner.
12.	Valse	"Puppen"	Bayer.
13.	Selection	"The Gondoliers"	Sullivan.

God Save the Queen.

The Royal Criterion Hand-Bell Ringers and Glee Singers (Conductor, Mr. Harry Tipper) gave a concert in the Fossil Mammalia Gallery.

PART I.

Bells	March from "Athalie"	Mendelssohn.
	or "Marche aux Flambeaux"	S. Clark.
Part Songs.	"Lovely Night"	Chwatal.
	"Summer Eve"	Hatton.
Bells	"Dorothy Valse"	Edith Cooke.
Glee	"By Celia's Arbour"	Horsley.
Bells	"Le Charme Gavotte"	Le Thière.
	or "Queenie"	Musgrave.
Part Song	"Comrades in Arms"	A. Adams.
Bells	National Selection	
Part Song	"I am so Nervous"	Truhn.
Bells	Imitations of Village Chimes, introducing two or three well-known Hymn Tunes, Chiming, Firing, Changes, &c.	

PART II.

Bells	"En Revenant de la Revue" (Boulanger March).	Désormes.
Song and Chorus	"A Sailor's Song"	Kunze.
Bells	Operatic Selection	Donizetti.
Part Song	"Absence"	Hatton.
Bells	"Merry Bells Polka"	Godfrey.
Part Song	"Sweet and Low"	Barnby.
Bells	"Blue Bells of Scotland" (With variations).	
Humorous Trio	"Crows in a Cornfield"	Harrington.
Bells	Selection of Irish Airs	

The number of visitors attending the *Conversazione* was 2,837.

CANTOR LECTURES.

SOME CONSIDERATIONS CONCERNING COLOUR AND COLOURING.

BY PROF. A. H. CHURCH, M.A., F.R.S.

Lecture I.—Delivered March 17, 1890.

SYLLABUS.—Definition of terms—Constants of Colour—Primary Colour Sensations—Classification and Nomenclature of Colours—Luminosity of Pigments—Translation of Colours into White, Greys, and Black—Effects of Varying Illumination—Dichroism—The Chromatic Circle—Chromatic Equivalents.

It was after considerable hesitation that I accepted the honour of addressing the Society of Arts on the subject which is to engage our attention to-night, and on the two remaining Monday evenings of the present month. I was doubtful as to the freshness of my material and as to my ability in presenting my opinions to your notice. Then, too, I remembered that Captain Abney had handled some parts of this subject so ably and so recently, in the course of lectures which he delivered in this room in 1888. I felt, however, that if I could but succeed in developing your interest in the connection between the science of colour and the art of colouring, I might perhaps be justified in acceding to the request of your Council.

The syllabus of the course indicates the limited range of these lectures, and shows that they make no pretension to an exhaustive treatment of the subject of colour. To my "Manual of Colour," published in 1887 by Messrs. Cassell and Co., I must refer my auditors for a systematic exposition; in this place I purpose developing some only of the topics discussed in my book, especially in relation to our everyday surroundings. But I cannot refrain from expressing the great debt I owe to the "Modern Chromatics" of Professor Ogden Rood, published just eleven years ago. You will notice how often I have to cite his authority and to quote his results.

Definition of Terms.—The sense given to certain terms, which will be freely used in these lectures, ought to be explained at the outset.

The essential difference between tones lies in their brightness or luminosity, that is the amount of optical sensation caused by a given area. Tints contain differing amounts of white, shades contain differing amounts of black, broken tints contain differing amounts of grey—all these are tones; the particular descriptions I have given being so framed as to apply to coloured and uncoloured substances rather than to lights. When a series of tones is said to constitute a scale, it is formed by the addition of equal increments of the modifying element. Each hue admits of three scales—the reduced scale, made up of tints; the darkened scale, made up of shades; the dulled scale, made up of broken tints. Theoretically, each possible scale starts from the pure normal colour; practically, when we deal with pigments and other coloured bodies and not with lights, such a perfect starting-point is unattainable. It should be added that the tints of black and the shades of white are the greys, and that passage-tones are distinguished from the tones which constitute the above-named scales in one respect only; they pass by imperceptible gradations from the beginning to the end, and not by definite steps of ascertainable value.

Constants of Colour.—Of these there are three, namely, hue, purity, brightness. The hue of a colour appeals at once to the eye; we endeavour to identify it, perhaps to name it, calling it red, orange, yellow, green, &c., and so on. The purity of a colour refers, in the accepted language of chromatics, to its freedom from white; in this sense no pigmentary colour is pure. In the spectrum, under certain conditions, we have pure colours. The brightness or luminosity of a colour is measured by the total amount of light sent to and perceived by the eye, and is independent of hue and of purity. Colours which do not sensibly differ from white, are therefore far removed from purity, are bright because the white light freely reflected from them produces more optical sensation than any positive colour. On the other hand, a pure colour is not necessarily a bright colour, for not only is the absence of white light the exclusion of the cause of the highest luminosity, but a pure colour may be so low in tone as to be barely recognisable.

When a colour is at once as bright and as pure as possible, it is called saturated; such a colour may be called "full" in speaking of pigments and other coloured materials. Its less pure tones are, as I have mentioned before, called tints, and are more or less "pale." Its less luminous tones or shades are more or less "dark." Such of its tones as are at once less pure than its shades and less luminous than its tints, are more or less "dull."

Of all the above terms there are two only which are applied in a manner somewhat different from that belonging to ordinary parlance. These two terms are shades of colour and purity of colour.

Primary Colour-Sensations.—Colour is, we know, an internal sensation, and has no external and objective existence. It originates, in all the cases which we purpose discussing in the present course of lectures, in the impact on the optic nerve of that energy or mode of motion which we call light. Certain waves or vibrations which affect the nerve-fibrils of the eye are translated by the brain into colour. I do not intend to place before you the various theories which have been propounded as to the method and mechanism of this translation; they involve numerous intricate and obscure physical, chemical, physiological, and psychological problems. But I ask you to accept, as the best of all working hypotheses, the view of the subject taken by Dr. Thomas Young in 1802, and since developed by Helmholtz, Maxwell, and Rood. The idea that there are three primary colours must be abandoned, but that of three primary colour-sensations may be very conveniently accepted, at least provisionally. What selection shall be made has been debated on various grounds. Several triads have been chosen, but a certain red, a certain green, and a certain blue have been accepted by some of the most distinguished investigators of the subject. I venture to add my own testimony as to the superiority of the triad of red, green, blue, over that of red, green, violet. With lights which provoke these three colour-sensations we can obtain all the colours of the spectrum as well as the purples which do not exist therein. Equivalents—I say, equivalents, not equal quantities—of the standard or normal red and green produce the normal yellow; of the standard or normal green and blue produce the normal sea-green; of the standard or normal blue and red, the normal purple. Intermediate colours are produced when the quantities of the two lights, which are together received by the eye, are not equivalent. Thus with red and green an excess of red produces orange; with green, and blue, an excess of green produces a greenish sea-green; with blue and red, an excess of blue produces a bluish purple or violet. No tertiary colour is possible, the colours called tertiary by artists being broken tints of the three primaries and of the three normal secondaries. In fact, if you mix the three normal coloured lights in their proper equivalents together, you get nothing but white or grey if the brightness of the lights be small; and if you mix these three normal lights together in any other than equivalent proportions, you get tints of the primary or secondary colours—that is, these colours mixed with white. By using the initial letters of the various normal colours to represent their equivalents, we may place the above results in the form of equations, which we will give after the manner adopted by chemists:—

$R + G = Y$, or yellow.
$2R + G = O$, or orange.
$G + B = S$, or sea green.
$2G + B =$ greenish sea green.
$B + R = P$, or purple.
$2B + R = V$, or violet.
$R + G + B = W$, or white.
$2R + G + B = W + R$, or pale red.
$2R + 2G + B = W + Y$, or pale yellow.
$R + 2G + 2B = W + S$, or pale sea green.
$2R + G + 2B = W + P$, or pale purple.

An essential difference between the colours produced by mixing lights and those produced by mixing pigments consists in this, that the addition or commixture of lights produces increase of brightness, while the commixture of pigments diminishes brightness. This difference of result is caused by the fact that the mixture of two lights possesses the added brightness of each of its elements, while the colour resulting from the mixture of two pigments possesses merely the residual brightness left after a twofold or manifold absorption of light. For when blue and red lights are mingled on the retina, the eye receives the combined brightness of both; but when the blue and red pigments are mingled, the eye receives only that portion of the light which has escaped the absorptive action of both the blue and the red pigments. In this and similar cases the dulness arising from absorption is very marked, and an artist who wishes to secure the greatest possible brilliancy in his work avoids, wherever he can, the commixture of pigments, rather placing touches of colour side by side, so that the colours they severally reflect shall mingle on the retina; the works of Samuel Palmer, William Hunt, and J. F. Lewis may be named as illustrating this method.

But there is a second difference between the colours produced by mingling lights and those produced by mingling pigments. This difference is not one of brightness or of purity; it is a difference of hue. You know the effect of mingling yellow and blue pigments together on the palette is the production of a green, more or less decided and bright, according to the chromatic constitution of the two pigments employed. But the commixture of yellow and blue lights in equivalent proportions results in the production of white more or less bright—that is, either white or a shade of grey—according to the brightness of its constituents. If there be an excess of yellow light the colour produced is pale yellow; if an excess of blue, pale blue. You may prove this point by the use of Maxwell's rotating sectors. Take the same two pigments, chrome yellow and ultramarine blue, which mingled on the palette produce green—rather a dull green—and mingle the lights they reflect, by the method of rotation on the retina, and you get a white of low luminosity, that is, a grey. But, as in this case, there is not the double absorption produced by the commixture of pigments, the grey is brighter than the green made by such commixture, and you will have to add much black to it (by means of a third sector of black) to obtain the same low degree of luminosity by rotation. I have purposely selected for citation this case of the mingling of blue and yellow, because it is the crucial instance by means of which is most strikingly shown the difference in hue above-named, and it also serves to demonstrate the fallacy of the still prevalent notion that blue and yellow lights produce green. When green is formed by the mingling of two pigments, one yellow, the other blue, this result is attained by the suppression of the yellow and blue and the survival of the green which was present in both. So when white light, transmitted through a yellow and a blue glass, appears green, it is the residual green which has escaped absorption by both glasses which colours the emergent light. We know that the simple yellow of the spectrum, and the compound yellow produced by the mixture of red and green lights, affect the red and green nerve-fibrils of the retina in exactly the same way, and it is for this reason that we affirm that yellow is a compound colour-sensation, and not one of the three primaries. I do not now dwell further on this point, as I I have dealt with it at length in chapter vii. of my "Elementary Manual of Colour," to which I beg to refer you for a fuller treatment of the differences between mixtures of lights and mixtures of pigments. I ought, perhaps, to mention here that the advocates of the red-green-blue theory of three primary colour-sensations, while denying the truth of the explanations afforded by the red-yellow-blue theory of Brewster, do not contest the occurrence of the chromatic phenomena presented by the admixture of pigments, or by the transmission of light through coloured media, which Brewster's theory incorrectly interprets.

Classification and Nomenclature of Colours.—The simplest arrangement of colours must include white, a balanced or neutralised compound of two or more hues; black, the negative correlative of light and colour; and the positive hues, with their tints, shades, and broken tints. In bare outline it may be given thus:—

DARKNESS	....	Black.
LIGHT..	*Colourless*..	White.
		Greys, or shades of white.
	Coloured ..	Hues.
		Tints, shades, and broken tints of hues.

But directly we endeavour to enter into further details, to give quantitative values and appropriate names to our many materials, we are confronted by serious difficulties. Whites and greys must have their brightness determined; all other tones require the determination of the three constants of colour, namely, hue, purity, and brightness. The fixed lines of the pure normal solar spectrum enable us, it is true, to locate all pure and saturated hues save the purples. Prismatic analysis reveals the chromatic elements of any colour; the methods of shadow photometry enable us to ascertain relative luminosities, but the intelligible expression of our results in reference to definite standards has not yet been attained. The problem is, moreover, greatly complicated by reason of certain modifications of tone or of hue caused by contrast, dilution with white, &c., &c., as well as by the immense number of colours, with their shades and tints, which the human eye is competent to distinguish.

Of the modes of classifying colours, the cone of W. von Bezold and the cube of W. Benson have many merits, but are not free from limitations and even defects. The colour-cube may be described in a couple of sentences, so far at least as its principle of construction is concerned. At one solid angle of the cube black, or the absence of light is placed, at the opposite solid angle white. At the three solid angles nearest to black, the full red, green, and blue are respectively placed, while at the three corresponding and opposite solid angles nearest to white the three complementary secondaries occur, namely, sea-green, purple, and yellow. The beautiful diagrams in Mr. W. Benson's "Principles of the Science of Colour" will fully explain the position of tints and shades in the cube.

The chromatic arrangement of Chevreul is vitiated by the adoption therein of the erroneous theory of the red-yellow-triad, nor are the hues represented referred to a definite standard. Radde's colour-chart, though nominally based on certain spectrum colours, lacks precision in plan and execution. The scales of Lovibond's tintometer are represented by numbered and named glasses, to a certain arbitrarily-fixed pale tint of which the value of one unit is given, and then the true chromatic elements of these glasses have not been determined.

The nomenclature of colours is intimately connected with their classification. It has difficulties all its own owing to (1) the shifting meaning of well-known colour names; (2) the difficulty of coining new names. Purple sometimes means dark blue, sometimes a colour half-way between violet and crimson. The old German verb *bleuen*, to strike or beat, has originated the modern German *bläuen*, and there is no longer a distinction between the procedure of the schoolmaster and the laundress, though *blauen* is given in some dictionaries for to dye blue, *bläuen* to beat blue, but *bläue* is the colour blue. The system, if such it can be called, of the mineralogist Werner (1774) included 92 terms arranged in nine groups. It lacks accuracy and orderly sequence, but is of interest in showing the use of terms for designating colours derived from certain typical, animal, vegetable and mineral substances, the hues of which vary but little. (See "Colour," page 63.)

The long list of colour-names given to silks by the Lyons manufacturers will furnish some expressive terms, but many of the names are quite arbitrary and fanciful. R. Ridgway's "Nomenclature of Colours for Naturalists" (Boston, U.S.A., 1887), is useful in giving at once many colour-names, and actual water-colour washes of pigments representing them. Unfortunately, many of these names are very vague (dahlia, aster, phlox), and they are placed in an order based on no recognisable chromatic system. The 51 degrees of the *cyanometer*, for measuring the blue of the sky, serve to define its tone only, not its hue nor its purity.

We want an international colour conference, in which artists, manufacturers, and scientists shall be represented. We want an agreement upon the names to be assigned to a number of different hues. We want representations of these standard hues reproduced in enamel, preserved like our standards of weight and measure, and distributed to every educational institution in the United Kingdom.

For my own part, I should be content to employ a combination of the systems of name and of number in the nomenclature and classifying of colours. The importance of having a definite nomenclature, of quite intelligible character, at our disposal, when we are talking or writing about the decorative employment of colour, is so important that I venture to make a few suggestions which may tend towards the attainment of this object.

Let, then, equivalents for the full red, the full green, and the full blue (as already described), be represented by the symbols R, G, B, the seagreen, the purple, and the yellow, which are the several complementaries of the above hues, being similarly expressed by the symbols GB, RB, and RG. The capital letter represents the hue; where no number is subscript, 1 equivalent is meant; for lower or higher luminosities decimals are used. If the sea-green, to select one instance, inclines towards green, that is, has more than one equivalent of green in it, we may easily express this modification of blue by a fractional addition to the symbol for green, and a simultaneous fractional subtraction from the symbol for blue. Such a series would result as this :—

GB = Seagreen.
$G_{1\cdot1}\ B_{\cdot9}$
$G_{1\cdot2}\ B_{\cdot8}$
$G_{1\cdot3}\ B_{\cdot7}$
$G_{1\cdot4}\ B_{\cdot6}$
$G_{1\cdot5}\ B_{\cdot5}$ = Greenish Seagreen.
$G_{1\cdot6}\ B_{\cdot4}$
$G_{1\cdot7}\ B_{\cdot3}$
$G_{1\cdot8}\ B_{\cdot2}$
$G_{1\cdot9}\ B_{\cdot1}$
G = Green.

The corresponding modifications in the five other principal series of colours would be expressed in a similar manner, the symbols, &c., being used exactly in the same way as in chemical notation. In order to obtain a scale in a concrete form, I would recommend the use of Maxwell's rotation method, by which each step in the gradation could be matched. I would use for the series between sea green and green two discs painted with as near an approach as possible to the full normal green and the full normal blue, and the former should be increased and the latter diminished (in the form of sectors) in accordance with the system I have suggested. The rotation colour produced at each step should be copied, or rather matched, and would then take its place in the series with a definite symbol attached to it. By the introduction of a white sector similarly treated, the tints of any colour could be made to match; with a black sector the shades, with a black and white sector the broken tints. The symbol for black may be conveniently called Z, that for white should be R G B or W, as the case may require. But it is also possible to express the shades of a colour by reducing its luminosity, and the broken tints by at once reducing its luminosity and adding white. Here are the symbolic expressions or formulæ for such changed hues:—

$S = GB$ = Seagreen.
$S_{\cdot 9} = G_{\cdot 9}\,B_{9}$ = A shade of, or darkened, Seagreen.
$SW_{\cdot 1} = GBW_{\cdot 1}$ = A tint of, or a pale, Seagreen.
$S_{\cdot 9}\,W_{\cdot 1} = G_{\cdot 9}\,B_{\cdot 9}\,W_{\cdot 1}$ = A broken tint of, or a dull, Seagreen.

In the case of pigments or other coloured materials the proposed symbols, though quite exact enough for any purpose for which they are employed, will not admit of accurate analysis. This is due to the fact that no pigment reflects a pure coloured light, there is always some white mingled with it, rarely less than 20 per cent. of the whole. And even with coloured lights there are also variable sources of error, for the addition of white light to coloured light, and also the reduction of its luminosity, alters the original hue. To this change, which occurs also with pigments, and often in a very conspicuous manner, I shall invite your attention shortly.

Luminosity of Pigments.—One often hears the remark with reference to a work in black and white, an etching or line-engraving, for example, representing a coloured picture, that it has got good colour in it. Such an expression may be interpreted to mean that the relative tones of the original are preserved in the copy, and suggest the force of the original colours. Now it requires much experience and singular skill thus to value and interpret the relative luminosity of differently coloured portions of a painting. An aid in the work of translation is afforded by making determinations of luminosity or brightness by means of shadow-photometry, or by comparing the brightness of various white and coloured materials with the brightness of greys of known composition. The latter method, though not very easy or very exact, involving the use of black and white sectors in the rotation apparatus, gives results which are, at all events, approximately true. These results represent the comparative luminosities of the particular specimens of pigments, &c., employed, and vary somewhat with the method of applying the pigment, its thickness, and the medium (if any) used. The following figures were obtained in this way, some by Professor Rood and others by myself:—

Chinese white, dry, in thick layer on pastel paper	100
Plain white paper	90·9
Whatman's paper (not hot-pressed)	88·2
Chrome yellow, pale water-colour wash	73·0
Emerald green, pale, in thick paste	44·2
Cobalt blue, water-colour wash	32·2
Vermilion, in thick paste	23·4
Natural Ultramarine	8·3
Artificial Ultramarine	6·9
Black paper	4·7
Lamp black, dry, in thick layer or pastel paper	·8

I cannot help thinking that a more extended series of comparative luminosities would prove useful to the translators into black and white of works executed in colour.

Effects of Varying Illumination.—The very considerable alteration of appearance experienced by coloured materials when the hue of the light by which they are rendered visible is changed, is rendered familiar to us by the case of pictures and dresses, seen first by candlelight and then by ordinary daylight. We discover that what we thought was purple is really violet, crimson is purple, green is blue, and so forth. The deficiency of the more refrangible rays of the blue end of the spectrum, and the superabundance of the less refrangible rays of the red region in the light of burning oil and gas, and even in that emitted by incandescence electric lamps, furnish the explanation of these changes. It is of course more conspicuously evident when we view richly and variously coloured objects in a light which is virtually monochromatic. The pure orange yellow of sodium cannot furnish the vibrations to which the majority of hues are alone capable of responding; only what is yellow can be seen, and even in this case not the yellow compounded of red and green vibrations. But I must not enlarge upon this point, as it has been often treated, and at length, elsewhere; and I want to direct your attention to those changes of hue in coloured objects which are caused by alterations, not in the hue of the incident light, but in its brightness. The observant student of Nature will have learnt that the hues of many-coloured objects are most characteristically brought out by a comparatively moderate illumination. The chief cause of this phenomenon is often traceable to the large excess of unaltered white light, which such objects reflect or scatter when the illumination is intense, while when the illumination is moderate it just suffices to develop properly the particular hue of the material. I recollect a case in point. Wishing one day to show to a connoisseur in precious stones a fine aurora-coloured zircon, which had lately been cut for me, I took the specimen into the sunshine. The colour was so altered and so impoverished that my pride in the recent acquisition was humbled; the stone was distinctly inferior to a similar specimen in the British Museum. This pallor was not the result of the glittering reflections from the polished facets of the gem, but the coloured light reflected to the eye from the lower facets was greatly reduced in purity by much admixture of white light. Out of the strong light the specimen resumed its rich and beautiful appearance, and showed, moreover, not only a much deeper but a much redder and less yellow hue than when sunlight fell upon it. Painters have long been familiar with such changes of hue. If you examine the works of the great colourists of the Italian schools you will see many striking examples of their appreciation of this natural phenomenon; indeed, I may say that these changes of hue with changes in the brightness of the illumination have been not infrequently much accentuated, even greatly exaggerated. At all events, artists have long known that the high lights of a self-coloured drapery cannot be properly represented by merely adding white—that is, by forming tints of the same hne—although it does indeed sometimes happen that the addition of white paint to one having positive and strong colour brings about changes of hue analogous to those we have been considering. Be it remembered that I am not now speaking of those purely accidental modifications of hue which are caused by reflections from coloured objects, and which often cause a white drapery to assume the beautiful orient tints of the pearl.

If increase of light above what we may call a normal standard (one capable of showing in perfection a colour) effects a change in hue, so also does decrease of light, although in an opposite direction. These changes of hue are well brought out in the following Table:—

Decreased Light.	Standard Light.	Increased Light.
Purplish	Red	Scarlet.
Red	Scarlet	Reddish Orange.
Brown	Orange	Yellow.
Olive Green	Yellow	Paler Yellow.
Greener	Yellow-Green	Yellower.
Greener	Blue-Green	Bluer.
Violet-Blue	Blue	Turquoise.
Violet	Violet-Blue	Blue.
Violet-Purple	Violet	Bluer.
Purplish-Violet	Purple	Red-Purple.

Similar changes of hue occur when coloured lights instead of coloured objects are reduced or increased in brightness. Thus by lowering the luminosity of a pure solar spectrum, there will not only be a selective reduction or even extinction of some of the constituent hues, but also a shifting of the position of the hues. The red will invade the orange region, so that the line D, for example, will be bordered by a kind of red-lead colour; the green will extend towards the sea-green, and even include the line F, and the pure blue will contract. We should then describe the darkened spectrum as practically consisting of red, green, and violet. By a further reduction of brightness the red will become brownish, and the green and violet dull. In the next stage the violet disappears, the green is more dim, while the brownish-red acquires a sort of chocolate hue. The last colour to be recognised is a very faint green hue. I ought to mention in this place that when white light is added to coloured light the changes of hue which occur are generally to be explained by the statement that they are such as would be produced by a slight admixture of blue light with the white light.

The bearing of these observations upon pictorial and decorative work in colour are obviously of considerable moment. If we want to be sure of the chromatic effect of a decorative scheme we must arrange and modify its elements in such a way as to adapt it to the usual illumination of the apartments in which it is to be carried out; and here one curious result may be noted. In a very dimly lighted room, saturated and comparatively pure colours may yield delicate and refined harmonies, while the same colours in a blaze of strong daylight, or direct sunshine, may also lose their garishness because of the large amount of white light which then becomes mingled with the proper hues they reflect. But with a medium illumination these saturated colours, if freely used, become intolerable, just because they are perceived in their original strength. We thus learn how it is that a scheme of colouring, which seems exquisitely choice when occurring in the dimly lighted apartments of a Cairo or Damascus house, may become to the last degree crude when transferred to the full illumination of an English home, where the walls are pierced with large windows of plate-glass admitting floods of light. The employment, under such altered conditions, of colours saddened with black and dulled with grey, has been long recognised and practised as one of the easiest ways of modifying the crude effect of such chromatic arrangements. If saturated colours are still used we reduce their area, or employ them in such small and involved touches that the mingling of their hues produces what Owen Jones called a neutralised bloom.

Before I leave this important subject (of the effects of varying degrees of illumination upon the hues of objects), I wish to direct your attention to a very simple and decisive class of experiments, by means of which some of these changes of hue of which I have spoken may be recognised. You need only take some pieces of richly coloured material, paper, cloth, or silk, of uniform hue, and partially crush and fold them, so as to get various portions illuminated in different degrees. An orange coloured silk will look yellow in its high lights, and brown in its hollows. A blue paper will appear violet in its shaded parts, and of a purer blue, or perhaps of a somewhat greenish blue, in its projecting portions. A crimson cloth will seem scarlet where it catches most light, and crimson where it reflects the least. These changes of hue are in part due to errors of judgment, but they are none the less real.

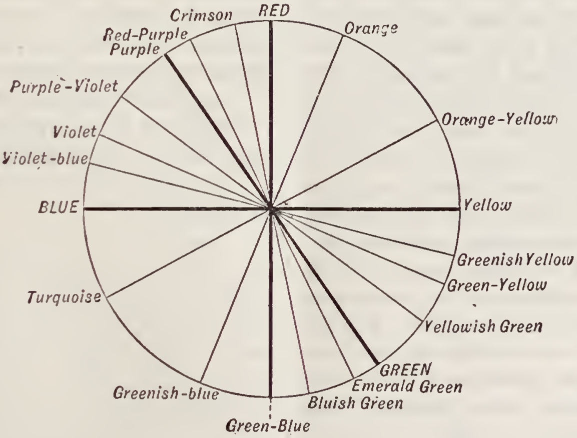
Our next subject for study is intimately allied with that we have just been considering. I regret that the narrow limits of my available time will permit me to give little more than the barest reference to it. I refer to the alteration of hue caused by the addition of white, of grey, and of black to a pigment. White added to a red pigment does not usually produce just a paler tint of red, but the new tint varies in hue, tending in some cases towards crimson, in others towards scarlet. The dilution of a transparent red pigment with a colourless medium—that is, attenuation of its thickness—produces analogous alterations of hue. Similar changes are caused in pigments of other colours by dilution and by commixture with white substances. Some of the changes produced by adding black are perhaps more striking. Rood found that, on mixing carmine with lamp-black, the mixture on the palette was more purplish in hue than the colours obtained by mingling the pigments optically by the method of rotation. This approach to purple was of course due to addition, with the black, of more blue to the carmine. An analogous observation, also due to Rood, relates to the admixture of black with white. Black pigments as free as possible from any tinge of positive colour are generally observed to yield a bluish-grey when mixed with white pigments. This result has usually been attributed to the fineness of the particles producing a blue by the same action on the light as an opalescent medium exerts. But Rood found that when white and black are mingled optically on a rotating disc, the grey they yield is matched in hue (not in brightness) by a white disc into which much blue (in one case 17 per cent.) has been introduced by means of a sector covered with a strong wash of indigo.

Dichroism is the next topic for our study. This term has been applied to similar phenomena produced in similar ways. A liquid or solid is said to be dichroic when the light which is transmitted through it differs in hue as well as in tone when the thickness traversed differs. Many liquids, such as solutions of double potassium and chromium oxalate, and potassium permanganate, well illustrate the phenomenon, so do many solids, such as copper sulphate, and several kinds of coloured glass and gelatine films. But there is another kind of dichroism occurring in solids which are not optically homogeneous. Many crystals are dichroic, or even pleiochroic, for when white light is sent through them in different directions it suffers thereby different selective absorptions, and so the emergent beams are differently coloured. The ruby, the emerald, and the tourmaline amongst precious stones are characteristic examples of this group of dichroic phenomena. Even a third class or group may be named, where the light transmitted differs in colour from that reflected and scattered, solutions of chlorophyll and of uranin, and the solids uranium glass and fluor spar belong here.

The first class of dichroic phenomena (depending upon the thickness of the coloured medium) is largely concerned with the production of beautiful quality in colour, as we shall see in the next lecture. It depends upon the increasing absorption of certain of the constituents of white light with increasing thickness of the medium. Thus, a solution of blue vitriol or, better still, a crystal, allows blue, green, and yellow light to pass through it if it be thin, but when thick only blue. Analogous phenomena are shown by purple films of gelatine, and by a solution of chromium potassium oxalate. These are cases of increasing selective absorption where waves of certain coloured lights can pass in some measure through weak solutions or thin layers, but are at last completely stopped or absorbed by layers of increased thickness.

The Chromatic Circle.—I can dwell no longer on this very convenient mode of arranging an orderly sequence of colours than will just suffice to explain the uses which I shall have to make of it in subsequent lectures. The disc of which our chromatic circle is the boundary may be regarded as the base of a colour cone, differing from that of von Bezold in the approximately correct angular positions accorded to the several colours which find place in the circle.

I have followed in the main the construction given by Rood to the chromatic circle, but I have not adopted his nomenclature, except in a few cases, while I ought to have used capital letters to indicate the hues corresponding to the three primary colour-sensations, and have emphasized these and their complementary secondaries by joining them by diameter lines of extra thickness. (See diagram.)*



Professor Rood determined the position of his normal red ("spectral red"), in a pure solar normal spectrum, and found it to be at 285, when the space between the fixed lines A and H was divided into 1,000 equal parts. Similarly his normal green is situated at 600, and his natural ultramarine at 785. His normal blue was taken at a point nearer the blue-green side of lapis-lazuli than that which I am able to accept. The three primaries I adopt are approached very closely in hue by the following pigments:—

Crimson Vermilion, for the red.

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* This diagram is reproduced from "Colour," p. 91 (Cassells.)

Emerald Green with a trace of chrome, for the green.

Pure Natural Ultramarine, for the blue.

Putting aside the questions of purity and of brightness, each one of these three primaries is neutralised, so far as hue is concerned, by one of the three secondaries, thus – Red, by green + blue or seagreen; green, by blue + red or purple; blue, by red + green or yellow. Thus the pairs, red and seagreen, green and purple, and blue and yellow, are what we call complementary colours, and united produce in each instance white. But of course there are an infinite number of complementaries, the pair of colours at each extremity of every diameter of the circle having the right to be so designated. This, however, is a subject to which we must return in the next lecture, and so I wish now to confine our attention to two other matters—the angular intervals which separate the selected colours to which I have assigned names, and the doctrine of chromatic equivalents.

In the earlier attempts at arranging colours in a circle, an inaccurate and quite arbitrary plan was adopted of placing the three primaries at three points equidistant from one another. Supposing, however, that we obtain a normal diffraction spectrum, and merely glance at the position which our three selected fundamental hues occupy, it will be immediately obvious that the green is separated from the blue by a smaller interval than that which divides it from the red. And if we take the numerical differences obtained by comparing the wave-lengths of the three fundamental hues, we shall arrive at the same conclusion. It is by fixing the spectral position of the pigments which most nearly approach these fundamental hues, and consequently learning their corresponding wave-lengths, that we are enabled to assign approximately correct angular positions on our chromatic circle to the pigments in question. For the practical purposes we now have in view, the allocation of proper positions to our most characteristic pigments is the problem which our chromatic circle is intended to aid in solving.

Chromatic Equivalents.—Still dealing with pigments, we may ask—What areas of complementary pigments neutralise one another's hues? and—What are the equivalents of the three fundamentals as represented by the corresponding pigments? We can answer these questions with a sufficient degree of accuracy by means of rotation-experiments with sectors suitably painted, using such areas of the different pigments as shall produce a neutral grey. Here is one set of results thus obtained with a circle divided into 100 equal degrees:—

Red (crimson vermilion)	38°3
Green (emerald green and chrome) ..	35°0
Blue (natural ultramarine)..........	26°7

On rotation these sectors produced a grey equal to that derived from 25° white (paper), with 75° black (paper). This large quantity of black shows how great a stride towards darkness is made when pigments (owing their colours to selective absorption) are used. From the above chromatic equivalents, reduced to their simplest expressions, we get the following equations:—

Red = 12. Green = 11. Blue = 9
Red + Green = Yellow = 23
Green + Blue = Seagreen = 20
Blue + Red = Purple = 21

It will be remembered that Field, by the erroneous method of combined absorption through coloured glasses, found the following equivalents:—

Yellow = 3
Red = 5
Blue = 8

And on these equivalents, widely as they differ from the truth, have been based those calculations generally current amongst colourists as to the proportionate areas of coloured surfaces, by which a chromatic balance and the so-called "neutralised bloom" are to be secured.

I may add here that Rood, employing a red paper of moderate brightness along with emerald green and artificial ultramarine, obtained for these pigments the following values in degrees:—

Red = 50. Green = 31. Blue = 19.

The neutral grey these sectors produced on rotation was matched by the rotation mixture of 13 of white (paper) and 87 of black (paper). These values differ, as one expected they would, from those I previously gave, but they lend no support to the figures of Field. On the contrary, they correspond to the ratio—

Yellow, 81 : Red, 50 : Blue, 19;

while Field's figures, multiplied by 10 for the sake of easier comparison, are—

Yellow, 30 : Red, 50 : Blue, 80.

Next Monday I purpose discussing further the subject of complementaries and of contrasts, inviting your attention also to various arrangements of colours in association.

Miscellaneous.

◆

THE AURIFEROUS DEPOSITS OF PERU.

Her Majesty's Minister at Lima says, in his last report to the Foreign Office, that in the mountain ranges of Peru, in the vicinity of the seaboard, whenever the rocks are of a crystalline character, gold is found in veins of quartz, which has been introduced into the granite and syenite. In this belt almost all the spurs of the Andes are of the above formations, and the auriferous quartz is almost invariably accompanied by oxide of iron and mica. The proportion of oxide of iron associated with the auriferous quartz presents considerable variations. Every possible form is met with, from white quartz, permeated with small ferruginous spots, to a reddish rock so charged with oxide of iron that the latter forms almost the whole of the auriferous mineral, the quartz appearing, as it were, in an accidental manner. The quartz in the auriferous minerals of the coast varies considerably in appearance, being found crystallised in prisms, in semi-crystallised grains, agglomerated with and united by oxide of iron, or in amorphous masses, more or less compact, or friable, with the appearance of scoria. In this district the auriferous quartz is often associated with other minerals, such as white talcose substance, smooth to the touch, with a silky almost silvery polish, with flakes of carbonate of lime of a laminar structure, and limonite of a resinous appearance. Lastly, on the coasts of Peru, gold may sometimes be discerned in copper minerals, as well as those mixed with chalk, copper pyrites, malachite, and silicate of copper. In the upland districts, where the formations exhibit the character of aqueous deposits, veins of gold are not only found in crystalline earths, but also in metamorphic rock, such as quartzites and slaty schist, introducing themselves into the sedimentary and eruptive formation. In these veins the gold is sometimes in a pure state, as well as in pyrites, sulphuret of iron, or accompanied by other metallic sulphurets more or less auriferous, copper pyrites, panabase, bournonite, galena, jamesonite, &c. Gold in the mountain ranges is found in veins and threads, and in the alluvial districts the same in flakes and grains—auriferous deposits which are known to the country people by the names of *rebosaderos* and *aventaderos*, also as *lavaderos*—the above, however, do not occur on the seaboard. In the Cordillera Oriental, in the district called the Montaña, gold is usually found in quartz veins, injected into talc and clay slate by upheaval of crystalline rocks. The quartz which accompanies the gold in this district is white, and occasionally exhibits marks of oxide of iron, but the latter is never found in the same abundance as in the auriferous minerals of the seaboard. The above-mentioned quartz, more especially in the province of Sandia, sometimes exhibits strains of mispickel or arsenical pyrites. In this part of Peru there are important beds of auriferous soil, and it is from hence that the greater number of nuggets have been extracted.

PRESENT CONDITION OF SILK CULTURE IN FRANCE.

With reference to the recent demand of certain delegates representing the agricultural, and especially the silk-growing, industry of Southern France for a protective duty upon imported cocoons and raw silks, with certain restrictions upon silk manufacturers in respect to "loading" their goods in the process of dyeing, the United States Consul at Marseilles gives a sketch of the history and present condition of this branch of French industry. The cultivation of the mulberry-tree for the rearing of silkworms began in the south of France early in the seventeenth century, but it was not until 150 years later that the industry became important or largely profitable. By the year 1780 the annual product of cocoons had risen to 6,600,000 kilogrammes, which were then worth about 2s. a kilogramme. This was a lucrative result in those frugal times, and the business continued to flourish until 1853, when the crop reached 26,000,000 kilogrammes at about 3s. 9d. the kilogramme, thus adding a sum of about £4,700,000 to the wealth of the rural classes. The country was admirably adapted to the growth of the mulberry-leaf, the warm dry climate of Provence and Comtat Venaissin was favourable for the worm; the labour of raising the cocoons and reeling them could be performed by women, aided to some extent by children and aged people, thus entailing scarcely any increase in the expenses of the farm, and the permanent prosperity of the industry seemed for a time assured. Then a series of disasters began. The peasants in their eagerness to raise every possible silkworm, had for years overstocked their premises, and in the crowded, ill-ventilated, and often dirty and neglected *magnaneries* the worms degenerated from year to year until they became a prey to several new and destructive diseases. The most serious of these were the *muscadine*, which was thought to have been imported with silkworm eggs from Turkey, and the *pebrine*, a malignant cryptogamous infection, generated by the conditions above cited, and which is commoly cited in France as *la maladie*. The *muscadine* caused a loss of £800,000 in a single season. In thousands of cases every silkworm in a farmhouse or breeding establishment perished, and this disease was succeeded by the *pebrine*, which swept the silk growing district irresistably, until a discovery was made which provided a practical escape from its ravages. This discovery was a new and certain method of detecting the disease in the chrysalis, or moth which lays the eggs that serve as the seed for next year's growth of silkworms. By the time however (1880-81) that this remedy was generally known and practised, the situation had become in other respects almost hopeless. After the war of 1871 wages and the cost of living had greatly increased. Selling prices for farm produce of all kinds, which had formerly been ample, were no longer sufficient in many cases to pay the cost of production. The price of cocoons, which at one time had been as high as eight francs a kilogramme, fell to six and then to four francs, and even less. Discouraged by disease and low prices thousands of farmers rooted up their mulberry trees for firewood and devoted the ground to vines and other forms of culture. The skilled women, who had formerly gathered the leaves for the silkworms and reeled the cocoons, had gone to other employments at higher wages than the languishing silk industry could afford to pay. By this time French manufacturers no longer depended upon home-grown silk. During recent years important discoveries in the chemistry of silk manufacture had enabled the spinners by skilful dyeing and "loading" their goods with gums and mordants, to use inferior grades of Japanese, Chinese, and Italian fibre, in place of the superior organzines which had given the fabrics of Lyons and the ribbons of St. Etienne their lustre and renown. It is urged that the manufactures were protected by high import duties, but the raw material which fed their looms was, and still remains, duty free. It is said that the weighting and loading of French silks has been carried to an extent which has injured their reputation, and not only disgusted French consumers of such goods, but has raised the question whether the use of so much low grade Asiatic fibre has been, after all, a blessing to the manufacturers of France. There is now a new and steady demand for better material, and the question has now arisen —why not protect the native silk growers and raise it at home? It is argued that it is solely due to the competition of foreign cocoons, and the increasing use of low qualities of silk, loaded with fraudulent dyes, that French silk culture has languished since Pasteur's discovery conquered the malady which had threatened its existence. The peasants of France, who hatched more than a million ounces of silkworm's eggs in 1872, used less than a quarter of that quantity in 1886. In conclusion, Consul Mason says, "The Government which had increased the duties on wheat and cattle, left the agriculturists without protection, and, seeing no hope of relief, many have given up the struggle, and either emigrated to South America, or flocked to the already overcrowded cities and towns. There are, in this consular district, six rural departments in which the population is steadily decreasing, and this decadence of agricultural prosperity involves a serious menace to France."

Notes on Books.

PRACTICAL GEOMETRY FOR SCIENCE AND ART STUDENTS.—By John Carroll. Tenth Edition. London: Burns and Oates.

This is the tenth edition of a little book described as "A Course of Lessons on the Construction of Plane Figures and Scales, Pattern Drawing, Geometrical Tracery, and Elementary Solid Geometry;" to this is added a section on the orthographic projection of points, lines, planes, and objects of simple form, and also on graphic arithmetic. It contains over 600 problems and exercises of a simple character intended for students who seek to acquire second grade certificates.

SEWER VENTILATION AND SEWAGE TREATMENT. By R. Harris Reeves. London: Sinclair, Tweedie and Co. 1890. Sm. 8vo.

The object of the author is to show that sewer ventilation is the first thing requiring attention in improved sanitation, and that the health of London will not be improved merely by the treatment of the sewage at the outfall if the generation of gases over the putrid matter in the sewers is allowed to continue.

Obituary.

LORD MAGHERAMORNE, K.C.B.—Lord Magheramorne died on Friday last, 27th June. James Macnaghten Hogg was born at Calcutta in 1823, the eldest son of the Right Hon. Sir James Weir Hogg, formerly Chairman of the East India Company, member of Council for India, and for many years a member of the House of Commons. He was educated at Eton and Christ Church, Oxford, and in 1843 he joined the 1st Life Guards. After sixteen years' service he retired from the Army with the rank of Lieutenant-Colonel. He represented Bath as a Conservative from 1865 to 1868, and Truro from 1871 to 1885. In 1885 he was returned for Hornsey, and retained his seat unopposed in 1886. On the death of Sir John Thwaites in 1870, Colonel Hogg, who was a member of the Metropolitan Board of Works, was elected chairman of that body, to which position he was annually re-elected until the Board itself ceased to exist. Colonel Hogg was created a K.C.B. on the opening of the Chelsea Embankment in 1874, and he succeeded to his father's baronetcy in 1876. In 1877 he assumed, by Royal licence, the name of M'Garel as a prefix to his surname, on succeeding to the Antrim estates of the late Mr. Charles M'Garel, of Magheramorne. In 1887 Sir James Hogg was raised to the peerage as Lord Magheramorne. In 1857 he married the Hon. Caroline Elizabeth Emma Douglas-Pennant, daughter of the first Lord Penryhn. Lord Magheramorne was elected a member of the Society of Arts in 1873.

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Proceedings of the Society.

CANTOR LECTURES.

SOME CONSIDERATIONS CONCERNING COLOUR AND COLOURING.

By Prof. A. H. Church, M.A., F.R.S.

Lecture II.—Delivered March 24th, 1890.

Syllabus.—Complementary Colours—Contrast of Tone and Colour—Harmonies of Colour—Combinations of Colour, Dyads, Triads, Tetrads, &c.—Separation of Related Hues—Throbbing or Pulsing Colour.

Complementary Colours.—The chromatic circle, to which I drew your attention in last Monday's lecture, is also, you will have seen, a contrast circle. On its circumference may be arranged a host of colours, limited in number only by the discriminative power of the human eye; these colours will be united in pairs by the diameters connecting them. Each colour has its complementary in that colour which is 180° off, that is, most remote in position from its own place on the circle; the pair united in equivalents from white; in other than equivalents one hue preponderates, but a tint is thus formed, for it is merely the uncombined excess which is perceived mingled with the white produced by the equivalents. Conventionally, we speak of white as present in the centre of the circle; in truth, it is present at different points on each of all possible diameters, in accordance with the value of each chromatic equivalent. And when we concern ourselves with pigments, we shall soon discover that their positions are variously disturbed by their divergence from normal standards of hue, purity, and brightness.

Besides the numerous complementary pairs which we can place and recognise *on* the circle, there are many corresponding pairs *within* its area situated on its diameters; these are complementary *tints*. And outside the circle, on the prolonged diameters, will be found complementary *shades*—that is, colours of reduced brightness.

There are several ways of learning the complementary of any hue. In practice we generally desire to ascertain the complementary hues of coloured materials; to this question we confine ourselves now. As such materials produce their hue by selective absorption, we cannot expect to obtain white from the union of the rays they send to the eye, but must be content with a neutral grey, often with a very dull or dark grey. One method of ascertaining the complementary of, say, a pigment, consists in erecting a sheet of glass in such a way that we can see directly through it the pigment of which we want to ascertain the complementary hue. We then cause an image of each of a series of trial complementaries to be seen by reflection on the glass, so that the direct and the reflected images coincide. When the patch of light thus produced has no positive hue in it, we know that our trial complementary colour is the true one. But this method is troublesome, and so we generally use another, mixing the lights reflected from the pair of colours by rotating coloured sectors. The case of brown paper is generally taken in order to illustrate this method. We prepare a disc of such paper, and associate it with such angular amounts of other discs as shall produce on rotation a neutral grey. In this particular instance Rood found that it required 45 parts of artificial ultramarine and 14 parts of emerald green to produce a greenish blue which should neutralise 41 parts of brown paste-board colour. The grey these complementaries yielded was matched by rotating 24 parts of white and 76 of black paper. Just look a little more closely into the chromatic constituents of this pair of complementaries. The three pigments—vermilion, emerald green, and artificial ultramarine—required in order to yield a grey need to be rotated in the proportions 36 : 34 : 30. But the complementary of our paste-board contained the emerald green and ultramarine in the ratio 14 : 45 or 9·3 : 30; consequently the paste-board must have furnished the equivalent of 24·7 parts of emerald green as well as that of 36 parts of vermilion. But these proportions of emerald green and vermilion, when mixed by rotation, produce an orange-yellow of rather low luminosity—a broken tint of orange-yellow—and it is by this term that we should define the colour of the particular brown paste-board. [It should be noted here that by the successive impressions of colours on the eye, produced in the rotation experiments, we do not get the added luminosities of the pigments, but only their mean luminosity; and that our bright yellow and orange pigments possess a degree of brightness quite out of proportion to that of most of our pigments of other hues.]

If we put aside the questions of brightness and purity, taking into consideration hue only, we may describe all complementary pairs as made up of—

(*a*.) *One Primary and one Secondary*, or of
(*b*.) *Two Secondaries.*

Examples of *a* are furnished by the pairs—

Red : Seagreen.
Green : Purple.
Blue : Yellow.

Among the countless instances of *b*, I name—

Orange : Greenish-blue.
Orange-yellow : Turquoise.
Greenish-yellow : Violet-blue.
Yellowish-green : Purple-violet.
Bluish-green : Crimson.

There is one characteristic of all true complementary pairs of colours—they do not affect each other's hues. They are already as unlike in hue as possible, and cannot therefore mutually modify this colour-constant. They may, and often do, modify their apparent luminosity and purity. So in the pair "blue : yellow," which affords, next to "black : white," the strongest possible difference of tone, the blue makes the yellow at once brighter and paler, while the yellow makes the blue at once purer and less luminous. The characteristic of the non-alteration of hue when the complementaries are placed in contact affords a criterion of the truly complementary nature of any pair of colours. For instance, in this diagram of true and false complementaries, in the pair "red : green," the red makes the green look bluer than it is, while the green makes the red appear to incline towards purple. So in the pair "yellow : purple," the yellow looks somewhat greenish, the purple somewhat violet; and in the pair "blue : orange," the blue inclines towards green, and the orange towards yellow. These are examples of the peculiar optical effect known as simultaneous contrast, in which two contiguous surfaces, which differ in one or more of the constants of colour, have such differences mutually enhanced or modified. Of such contrasts of hue, brightness and purity, I shall have something further to say directly, but I want to ask you first which of my columns of supposed complementary pairs commends itself to your judgment and taste as preferable? I do not say that the strongest possible contrasts of hue, as afforded by our approximations to the complementaries, are necessarily agreeable, but I do feel that the similar series constructed on the false basis of the red-yellow-blue theory is decidedly unpleasant: the angular intervals between the pairs should have been greater or less. Red with seagreen seems to be more agreeable to the eye than red with green; green with purple looks better than with yellow; blue with yellow better than blue with orange. That these effects are not wholly due to differences in brightness may be argued from this case of blue with orange, where I have tried to lower the saturation of the orange so as to make it brighter than the blue with which it is associated. But the inherent falsity of the red-yellow-blue theory precludes one from giving to these pairs of complementaries their proper share of brightness—assuming for the moment that we could really accomplish such a result with pigments.

Contrasts of Tone and Hue.—Contrasts are of three kinds, namely, contrasts of hue, contrasts of brightness, contrasts of purity. I have already directed your attention to contrasts of hue; the other two kinds of contrast now demand notice. The best illustration I can give you of contrast of tone will be one in which we shall produce simultaneously a series of greys. By means of this black figure mounted on a white disc we shall produce a series of optical mixtures of black and white, regularly increasing the white by five steps. The outermost ring of grey will be the palest tint of black, the innermost the deepest shade of white. But you will observe another and unexpected appearance produced in this experiment. Each ring seems to be itself united and shaded, although it must really be of one uniform grey. Simultaneous tone-contrast is produced, not by optical fatigue but by an error of judgment. The effect is enhanced by the difference of tone on each side of these contiguous rings, for the middle ring is bounded by a darker shade of grey on one side, and is there made lighter by contrast, while on the other side it is in contact with a paler tint of grey, and is there made darker by contrast. The immense importance of this phenomenon in pictorial and decorative art is well known; it, of course, takes place with positive colours as well as with negative. If in an engraving or Indian ink drawing a certain dark space seems monotonous and heavy a single touch of a darker shade will at once lighten and vary it, while just in the same way a lighter stroke on a tint which is too pale will enrich and deepen it. In both cases the result of simultaneous contrast will relieve the flatness of the work.

When positive colours come into the arrangement of differing tones the results may be indicated by means of a few diagrammatic figures. Suppose we begin by introducing a kind of brown in the form of a disc. This colour of medium depth is deepened by a smaller half-disc of white near its centre, and lightened by the contiguity of a corresponding half-disc of black. Again, suppose we place a small disc of full blue upon a larger disc half white and half black, the black will make the blue it touches less pure, that is, will lighten it, while the white will affect the blue in an exactly opposite way.

We now proceed a step further, and take two colours instead of one. Using the same reddish-brown colour as before, we place it on a disc of deep blue, and find that it becomes lighter in tone and less pure, while at the same time it acquires a distinctly yellow cast, having thus received a portion of the complement of blue. Similarly on an orange-red (red lead colour) disc, lighter in tone than its own, it appears deeper in tone, and assumes a somewhat greenish-blue cast, though this effect is but slight, owing to the addition of this complementary mainly serving to neutralise some of the red in the brown disc.

A third case may now be considered. We select for apposition two colours which are separated from one another by a comparatively small angular interval in the chromatic circle, and which are both somewhat bright. We find, as we might expect, that their mutual action as to alteration of tone is but slight, while their change of hue is more decided, each tending to recede farther from its companion by acquiring more of the complementary hue. Here visual fatigue and the warping of the judgment both conduce to the same result.

Harmonies of Colour.—I must now ask you to consider what are called chromatic harmonies. Chevreul's classification of harmonies under two headings — harmonies of analogy and harmonies of contrast—is somewhat arbitrary. All harmonies are in varying degrees harmonies of contrast. In every chromatic harmony there is contrast, contrast of hue, or of brightness, or of purity. Contrast generally, therefore, does not afford a criterion of classification. No fundamental difference really exists between those harmonies where change of tone or of hue is gradual and those where it is abrupt; it is a matter of degree, and is quantitative rather than qualitative. I do not see my way to improving the arrangement which I proposed in my "Manual of Colour" (pp. 134 to 139). I suggested arranging the various possible harmonies upon the arc of a circle, placing the harmonies of close analogy at one end, the harmonies of strong contrast at the other:—

1. The passage, by insensible differences, of the tints, shades, or broken tints of one hue, from light to dark.
2. The gradation by small but regular, definite, and perceptible steps, of the tints, shades, or broken tints of a single hue, from light to dark.
3. As in 2, but each step separated by a neutral element, as white, grey, or black.
4. The passage, by insensible differences, of one hue, or of its tones, into another related hue or its tones.
5. The gradation by definite steps of one hue, or of its tones, into another related hue or its tones.
6. As in 5, but each step separated by a neutral element.
7. The passage, by insensible differences, of one hue, or its tones, into another chromatically remote hue.
8. The gradation, by definite steps, of one hue into another chromatically remote hue.
9. As in 8, but each step separated by a neutral element.
10. The collocation of different tones.
11. The collocation of chromatically distant hues.
12. The collocation of chromatically distant hues separated by a neutral element.

The idea of seriation or gradation becomes more and more involved with that of decided change as we follow the sequence of these numbers; analogy gives place to contrast.

This classification may be illustrated by a few examples, but I have no time to develop the subject completely. And it must be noted that such definitions as I have offered are of use in the way of suggestion, but must not be allowed to fetter the imagination of the artist;

they cannot take the place of experiment, observation, knowledge, and sensitive perception of chromatic beauty.

I take three examples only; they will serve to illustrate Nos. 5, 6, and 7.

The diagram shows the gradation in three steps only, of yellow to orange (No. 5 above); and also the same gradation when the neutral elements, white, grey, or black, are inserted (No. 6). These cases furnish examples of the use of what has been variously termed "the dominant hue" and "the small interval." We may illustrate it by the budding foliage of spring, the changing hues of autumn, and the association of nearly-related hues in many flowers, as several kinds of daffodil.

My next diagram shows the passage of red to blue (No. 7 above). Really it is only a more extreme case of our No. 4, but there is not here a chromatic element common to the whole series of passage hues, for the red at one end contains no blue, and the blue at the other end no red.

Associated Colours.—Of pairs, or dyads, I must say a few words. These are of three orders, namely, complementary pairs, large-interval pairs, small-interval pairs. Complementary pairs, when their tones differ considerably, as in the case of deep red with bright sea-green; or when they contain much white, or are pale; or when they contain much black, or are of low luminosity; or when they are at once of low luminosity and contain white (that is, are broken with grey), are all, or may be, so adjusted as to be agreeable. Large-interval pairs are usually more difficult of management, and when both possess a full degree of saturation, are often unpleasant. Cases are afforded by red with yellow, orange-red with blue-green, orange with purple, orange-yellow with green, orange with green, and greenish-yellow with turquoise. The dilution of one of the pairs with a neutral element generally improves these combinations, but some of them, though so strong as to require moderation in use, are naturally excellent. Amongst these may be named red with blue, orange-red with blue, orange-yellow with violet, and blue-green with violet. In these cases, however, there is normally a considerable difference in the luminosity of the two colours associated in pairs. By beauty of material and of pattern some of the simplest dyads may yield exquisite effects, as in Italian velvets and brocades of the 16th century. Such dyads are yellow-green with medium violet, pale olive-green with deep indigo, leaf-green with deep blue, and pale leaf-green with deep amber.

The simplest triads contain two colours and a neutral. Suppose we desire to associate violet and blue we may interpose with agreeable effect between them white or a pale grey, but not black. The blacks available have a low degree of luminosity and so do not differ enough from the full blue and full violet we are using; moreover they become tinctured with an unpleasant rusty hue, the complementary of the blue or violet. Generally the poor and bad dyads may be improved by the introduction of a third element, while good dyads are often spoilt thereby. Good triads may frequently be secured by taking three hues rather widely separated from each other on the chromatic circle, and, as a general rule, two of these hues should be pale or bright and one deep or dark, or *vice versâ*. Except in special circumstances it will be easier to many of these triads when two of the members belong to the "warm" side of the circle and one to the "cold." I give a few good triads:—

Amber,
Cream,
Blue (medium).

Amber,
Blue (pale),
Crimson.

Flesh-red,
Blue (normal),
Olive-green.

Brick-red,
Indigo,
Sea-green.

Leaf-green,
Puce (deep),
Rose-grey.

Terra-cotta,
Maroon,
Sage-green.

Maroon,
Bronze-yellow,
Olive-green (dark).

Bluish-green,
Violet,
Red-ochre.

Leaf-green,
Violet,
Salmon.

Apricot,
Crimson,
Gold-brown.

Red (normal),
Gold,
Blue (normal).

Lavender,
Turquoise,
Blue (deep).

Other examples of triads, and of more complex colour-combinations, taken chiefly from historic and national chromatic arrangements, are—

1. Blue (deep), or Lavender (pale)
2. Gold-amber (Ancient Egyptian)
3. Vermilion-red in fine lines on 2

1. Lavender (pale)
2. White
3. Black
4. Red-brown (medium)
on ground of 5, orange yellow] 6, ochre-yellow (Assyrian)

1. Chamois-leather
2. Raw Sienna
3. Venetian Red
on ground of 4, black (Greek)

1. Blue (medium)
2. White
3. Red
4. Greenish grey
with outlines of 5, black (Moresque)

1. Silver
2. Gold
with outlines of 3, puce, all on ground of 4, pale emerald green (Indian)

1. Silver
2. Lavender
3. Emerald Green (medium)
with 4, white in bands and 5, black in lines (Irish MS.)

1. Silver (area = $\frac{4}{10}$)
2. Gold (area = $\frac{4}{10}$)
3. Red edgings (area = $\frac{1}{10}$)
4. Black ground (area = $\frac{1}{10}$)
(Irish MS.)

1. Lavender
2. Lemon-yellow
3. Crimson (medium)
4. White (in strap work)
5. Green (medium)
with as lines and ground, 6, black (Irish MS.)

1. Bluish-green (full)
2. Yellowish olive (medium)
3. Orange (pale)
4. Blue (full)
5. Purple (medium)
6. Crimson

1. Crimson (medium)
2. Salmon
3. Yellow (pale)
4. Yellow green (medium)
5. Yellowish olive (medium)
6. Maroon

And now I desire to draw your particular attention to one of those characters of good colour which is of supreme importance. You will understand the nature of this "quality" in colour when I have described and analysed illustrative examples. I begin by choosing a few cases in which it is either absent or irrecognisable. A surface of matt paint of one uniform tone and hue, and illuminated by a direct and colourless light, is confessedly prosaic and uninteresting; so also is a piece of self-coloured "surface" paper or a plain printed cotton cloth. All the materials are flat, and they exhibit no variations of tone or hue, or at least no perceptible variations. Of all the hues that can be chosen as examples of this point, perhaps the full red, the full green, and the full blue are the most telling; but the full orange and the full violet come very near to them. If the generally accepted theory of the three primary colour-sensations being red, green, and blue be accepted, we shall perhaps be able to suggest a partial explanation of the unpleasant appearance of a considerable surface of any one of the three above-named hues when alone in the visual fatigue of one set of optical nerve-fibrils which they severally cause. Orange and violet are, however, assumed to affect the red and green fibrils and the red and blue fibrils respectively. Yet in the case of these two colours (orange and violet), the stimulation of the two sets of fibrils which they each cause is not equal, for the orange has an excess of red in it, and the violet has an excess of blue. If we select other hues in which the two components are present in equivalent, if not in equal, proportions, the force of our argument is, I think, increased. Such hues are yellow (red + green), seagreen (green + blue), and purple (blue + red). Now it will be generally conceded that the contemplation of an *unmitigated* yellow is less displeasing to the eye than that of orange or red, seagreen than green or blue, and purple than violet. Such comparisons are, I confess, very difficult to make, and, without special contrivances for excluding all disturbing elements, they are quite inconclusive. With the pigments commonly employed for such comparisons, the varying amount of white light they reflect, and the presence of chromatic elements other than those we desire to compare, do more than imperil the accuracy of the result. And then the presence of backgrounds and surroundings modified the effects produced; these depend also very much upon the manner in which the coloured substances used are illuminated. Even with the spectrum-colours themselves a just comparison is by no means easy. I am reluctant to illustrate my argument by citing the case of certain sounds, because the analogy between colour and sound has been frequently pushed to unwarrantable lengths; yet I think I may say that an absolutely pure loud note of uniform pitch, without the simultaneous presence of those harmonious constituents which combine to form its *timbre*, would be no more pleasing to the ear than a pure full colour of elementary character is to the eye.

Hitherto, I have been speaking of full colours, colours, that is, which are intense and saturated, and also pure or unmixed with white. The current theory of colour sensation does, however, assume that there is *some* stimulation of all the three kinds of optical fibrils caused by each colour, however pure. Still the sensation, say, of green is caused by an immensely preponderating stimulation of the green fibrils over that of the blue and red fibrils. A corresponding statement may be made with regard to the sensations of blue and of red. In these instances, the fibrils not necessary to the production of the two sensations in question are even less stimulated than in the case of green, a difference which has been attributed to the median position of the latter hue in the spectrum and therefore to its intermediate wave-length. It is argued that the green nerve-fibrils which respond to the vibrations of green light are capable of responding, to a slight extent, to the vibrations of light on either side of green, but that the red nerve-fibrils are somewhat less affected by the impact of the vibrations at the other end of the spectrum, and *vice versâ*. In confirmation of this view I may mention the curious observation that the last colour to disappear when a continuous and normal spectrum is gradually reduced in luminosity is the green. That it appears finally as a grey, having but a faint tinge of green, is quite in accordance with theory. And it may not be out of place to observe in this connection that the full, nearly normal green, as represented by the pigment emerald green, is much more luminous than the full red as represented by vermilion, probably in a ratio approaching 2 : 1.

One reason, then, why pure white and the infinite series of tones of grey do not offend the eye as do certain pure, full, and luminous colours, may be traced to the equal stimulation of the three sets of optical fibrils which they cause. Tints of any colour—the full colour lightened with white; shades of any colour—the full colour darkened with black; broken tints of any colour—the full colour dulled with grey, come into the same category; for the stimulations they cause, though not equable like that of white and of grey, either approach equality, or are less energetic and one-sided than those of the full normal hues.

We are now in a position to offer some explanation, inadequate though it be, of the peculiar satisfaction afforded to the eye by one of the characteristics of beautiful colour. We call it "throbbing," "pulsating," "palpitating." This quality may be imparted to it in several ways, by which its dead uniformity is broken, or its *criant* effect is subdued. The fluctuation in question may be caused by—

Light and shade from inequalities of surface or irregular scattering of light.

Varying surface-reflections.

Passage from translucency to opacity.

Varying depth of hue.

Variations of hue limited to the "small-interval."

Several of these causes often conspire to produce throbbing colour in one and the same case, and they will be best illustrated by a few concrete examples.

The case of rough paper which has received a uniform wash of water-colour furnishes us with an illustration of the effect of light and shade as modifying hue. We will assume that the pigment has been so equally distributed that the hollows of the surface have not retained more than the elevations. Then we shall find, in the case of many pigments of full colour, that the hue in the hollows differs from that in the prominences. For instance, if French ultramarine has been used, the hollows will show a colour tending slightly towards violet, while the pigment on the elevations will exhibit a purer blue. In practice the effect will be augmented by the varying amounts of pigment which have lodged in different parts, the hollows retaining more than the elevations. The same wash of the same pigment on smooth paper will present a different appearance; and in order that the effect of the pigment on the latter may rival that on the rough, it will be necessary to introduce a second pigment, perhaps even a third. That the difference in question is not one of light and shade only may be proved by comparing the two kinds of coloured surface in a suitable instrument constructed on the principle of Lovibond's tintometer, and admitting of the examination of small isolated points or patches of colour, the chromatic analysis of these points will be found to vary not merely in depth but also in hue.

That the majority of painters in water-colours should prefer a comparatively rough paper for their work to the smooth sameness of Bristol board is not surprising. One admits of happy accidents of hue, and even involves them; the other demands the introduction of laboured effects, while the result, at the best, is inferior.

Our second cause has been called "varying surface-reflections." To illustrate it we will take a piece of porcelain. The glaze may vary in thickness; parts may be more perfect in gloss than other parts; it may even exhibit iridescence. A colourless glaze may produce modifications of the hue of the colours beneath it by reflecting from its surface in varying amounts the coloured rays which fall upon it from surrounding objects, or by itself decomposing the white light by which it is seen. In both cases its colour will be variously changed even when that colour was originally flat and uniform. I have in my mind, at the moment, a vase of old Chinese egg-shell porcelain of an amber-yellow. This colour is due to lead antimoniate, a substance which has become partially incorporated with the colourless glaze in the kiln. The surface reflection varies in intensity; in some places it reflects the incident white light unchanged, in others it shows iridescent colours, chiefly purple and greenish blue. The fluctuation of colour is produced by the mingling of the light which has passed through the yellow pigmentary layer and has then been reflected to the eye from the white subjacent ground with the light directly reflected from the glossy surface. From different portions of the surface we receive light of at least four different hues, namely, the original yellow; the same colour diluted with white; pale orange-yellow, where the original yellow hue is modified by commixture with the purple of the iridescence; and pale greenish yellow, where it is similarly mingled with the greenish blue rays from the glaze. Of course, in some positions, the iridescence alone can be perceived, just as in others the original amber-yellow alone is visible.

When a colour varies in transparency or opacity we get a third case of fluctuation. This variation is generally accompanied by variations in depth and hue, but it alone suffices to bring about the quality we are considering. Let us take an illustration from oil-painting. We shall require two pigments, one transparent, the other opaque. It will be difficult to match them exactly as to hue, but vermilion and a kind of madder red will answer sufficiently well. We spread a very thin layer of the latter upon a white or colourless ground; some distance off we prepare a similar patch of the vermilion; between the two we make a gradated mixture of the two pigments, and thus obtain the passage of a transparent colour into an opaque colour; yet the whole coloured area is a red, and a red which can be represented by one and the same numerical expression when referred to the wave length of the corresponding hue in the spectrum. But instead of employing these two pigments in the diagrammatic fashion, let us use them in pictorial or decorative painting by placing the two pigments side by side, or glazing with the translucent pigment, or scumbling with the opaque upon the same background. Only in some such way is it possible to suggest the throbbing colours seen in many natural objects, feathers, precious stones, marbles, &c. Of course in representing these we are not restricted to the use of a pair of colours of the same hue and depth; the limitations we imposed upon ourselves were intended merely to simplify the consideration of this third source of pulsating colour. Let me add that the fluctuation here is between two red lights, one of which reaches the eye after passing twice through a translucent red medium, while the other is produced by selective reflection from the surface of an opaque red solid. I say opaque, although in point of fact the incident light, or rather a part of it, plunges to some depth amongst the red particles of vermilion and passes through them, a chromatic selection being thereby made. And it is really in this manner that the light finally reflected to the eye by this pigment, having lost in selective absorption some of its coloured constituents, is red. I might cite many examples of the fluctuation of colour produced by the passage of an opaque colour into a transparent one or by the juxta-position of two closely related colours, one of which is due to surface-reflection, the other to reflection from an appreciable depth: the sea, for instance, when it shows the local blue colour of the water itself, and, associated with this, the reflected blue of the sky. The effects produced in certain textiles, such as linen and silk, damasks and velvets, partly belong here, but they are also connected with the variations due to inequalities of surface and to differing powers of reflection.

The fourth and fifth causes of the throbbing colour are to be traced to variations in depth of one colour, or to slight variations in hue; they may be fitly considered together, for in actual examples they are generally associated. Again, we may have recourse to Chinese porcelain for an illustrative example. There is a beautiful ceramic colour known as dragon's blood; its hue varies much in different specimens, and even in the same specimen, but the red element always largely preponderates. The red sometimes approaches a red-purple, that is, has a small proportion of blue in it; more often it oscillates between a crimson and the colour known in France as *garance dorée*. The crimson varies in depth. Sometimes it is a full and saturated colour, sometimes it passes into a paler tint, a kind of rich rose-pink. The *garance dorée* is a translucent red, which, when diluted, has a somewhat golden-red or orange-red hue. When we examine a good specimen of this kind of porcelain, we may sometimes detect the presence of all the colours I have named, as well as of their intermediate or passage tints. These hues are separated from one another in the chromatic circle by a very small number of degree; they illustrate the effect of the collocation of colours differing by what is called "the small interval." If the circle be divided into 100°, their extreme range will amount to about 10°. And the most extreme colours are not in juxtaposition, for one slides into another by imperceptible gradations both of tone and of hue. And a range so extensive as 10° is by no means necessary in order that the prosaic flatness of ordinary colour may be avoided; possibly a range of 2° or 3° may suffice, even if it be unaccompanied by variation of tone. Coloured glass, of good quality, may be chosen as affording an excellent illustration of the points now under consideration, but I reserve it for fuller consideration later on, although I may observe, in passing, that the fluctuations in colour of the transparent enamels on porcelain, and of glass, arise from the same causes, only that, as we look *at* porcelain and *through* glass, surface iridescence in the latter plays either no part, or a very small part, in the production of the phenomena in question. Of course I exclude from consideration glass intended to be looked at, that is, those vessels of glass, coloured or uncoloured, which owe their beauty of hue to the iridescence of their surface.

I have now shown, I trust, that throbbing colour is produced in more than one way, and that it is agreeable to the eye, even when we are unconscious of the elements that concur in its production, at least in part through physiological causes. I do not think these causes furnish an adequate explanation of the pleasure such colour affords, for its charm is doubtless connected with certain fluctuations of our judgment when any element of contrast in colour or in tone comes in, with the agreeable associations it recalls, and with its complexity and mystery. We do not see it all at once, nor do we instantly grasp its full meaning. Its effect may be likened to that of an intricate architectural vista, or of a range of distant mountains, or of the cadences in the exquisitely chosen language of a beautiful poem. I cannot but think that throbbing colour is as necessary to chromatic decoration as to pictorial art. You are familiar with the numerous and most useful coloured designs which illustrate Owen Jones's "Grammar of Ornament." Translate these flat and terribly prosaic figures from the uniformly coloured paints with which they have been printed into those precious materials—silk, and marble, and glass—which present delicate variations of tone and of hue, and at once the chromatic combinations are ennobled, changed from awkward prose into refined poetry fraught with varied interest. It is just in the same way that the sympathetic painter of landscape treats the clouds and the sky. He is not satisfied with white and grey for the former, and with blue for the latter. He does not merely gradate his tints, but suffuses his whites and greys with faint suggestions of amber and apricot, and rose; and varies his azure with hints of lavender and of aquamarine.

Miscellaneous.

THE TRADE IN ICE.

This industry is peculiarly American, for in no other country has the business of cutting and storing ice been so systematised and perfected. The interest has grown steadily from year to year, until it has attained large proportions, the annual production being counted in millions of tons, requiring in the aggregate, a large investment of capital in all the Northern States. It gives employment also to thousands of men and horses in the depth of winter when farming work cannot be carried on.

The loss in weight of ice by melting, evaporation, and breakage, is very great, and is an important item in the business, for, although ice may be gathered and housed at an apparently trifling cost, only a fractional part of this quantity collected is utilised. The loss by melting, carting, and retail vending being estimated at from 50 per cent. up to four-sixths of the entire amount stored.

The manufacture of artificial ice does not appear to affect the demand for the naturally formed article, where it is easily attainable.

In some years 12,000,000 tons of ice are gathered in the States. Along the northern shores of the lakes and tributaries over 2,000,000 tons are collected for the use of the trade; in New York, Brooklyn, and Jersey City, about 2,000,000 tons; in the New Zealand States, another 2,000,000 tons; in Philadelphia, 700,000 tons; in Boston and its vicinity, 1,000,000 tons, and in other parts of the United States over 2,000,000 tons. The best ice is that cut in December and January, the ice cut later being snowy and less dense. Ice that has been kept over for two or three seasons is considered preferable for export.

Ice is one of the chief productions of Massachusetts. The local use is old, but the shipments abroad were commenced from Boston early in the century by a Mr. Tudor, who first sent some to the West Indies, the Southern States, and even as far as Calcutta. In 1826 the shipments were only 4,000 tons; in 1836 12,000; in 1846, 65,000; and in 1856 had reached 146,000 tons. Since then the American shipments have never exceeded 65,000 tons a year. It is only in the last half of the century that the implements and machinery for cutting, transporting, collecting into ice-houses, storing, discharging, and lowering into the holds of vessels have been invented.

It is estimated that in America £8,000,000 are expended in a year on the ice trade, and that a similar amount is invested in the business. The ice-fields from which New York dealers draw their stock of ice extend from Rockland Lake, 253 miles up the Hudson, to Albany, embracing both sides of the river.

More ice is taken from the Hudson than from any other stream or body of water, not only in the United States, but in all the world. The total capacity of the ice-houses along the Hudson exceeds two and a quarter million tons, and in some years they are full, with 1,000,000 tons more stocked for early consumption; 12,000 men and boys, 1,000 horses, and 100 steam-engines are employed in getting in the crops in the two or three months between December and February. It may be taken to be worth on the average 4s. a ton.

The consumption of ice in large cities is about the following quantities:—New York, 700,000 tons; Boston, 100,000; New Orleans, 40,000; London, about 200,000; Paris during the season is said to use 400 tons a day. In the South American cities cheap ice is obtained from the Cordilleras. For the South of Italy and Sicily snow is stored in several caverns.

Importation of blocks of ice are received in England from Norway and America, but the quantity received varies. In 1888 we received 283,750 tons, chiefly from Norway. In some years the imports have reached 315,000 tons. Much ice is taken on board here by ocean steamers for use on the voyage, 8 or 9 tons at a time.

The export ice trade is chiefly carried on by Boston and Norway, the latter country supplying the English market with ice at lower rates than can be done by Boston. The average export from Norway is about 250,000 tons, valued at £50,000. In 1884 it reached 490,000 tons. The preservative properties of ice creates a large demand for this commodity. Dealers in fresh meat and fish would not know how to carry on their business in the warm season without ice. By means of refrigerators and cool chambers an immense quantity of fresh meat has been introduced from the River Plate and Australasia. Last year as much as 61,350 tons were received here.

As a medical agent in tropical regions, ice is deemed of the highest value, especially in cases of fever. Once regarded as a luxury, ice has now come to be held as indispensably necessary to the promotion of health and comfort.

After the United States, Russia is perhaps the largest consumer of ice. Throughout the summer ices are sold in the streets of every Russian town, and not only iced wine and iced beer, but iced tea is drunk in immense quantities. The short but excessively hot summer would spoil most of the food brought to market, had not the winter provided in abundance the means of guarding against such rapid decomposition.

In St. Petersburg alone there are said to be 10,000 ice-houses.

Ice is in great demand in all warm climates. In the Bombay Presidency, India, there are five companies for manufacturing and selling ice; in Bengal four, one at Lucknow, one in the Punjab, and one in Assam. In many parts of India, where the temperature sinks at night below the freezing point, ice is obtained by placing earthenware pans, filled with water, in shallow pits.

At Nagata, in Japan, over 2,000 people are said to gain a livelihood by selling snow-ice in the summer months. Holes for the snow to drift in are dug in the sand hills by the sea-shore, and thatched over at the end of winter. The snow has been known to last for two years.

Various industries in America require enormous quantities of ice in the conduct of their business. Many businesses, for instance, keep as much as 1,000 tons at a time in stock. Pig slaughterers also require large supplies. In New York State alone there are over 200 firms engaged in salting pork, each of which consumes from 500 to 1,000 tons of ice in a year. Butter merchants again, whether in a large or small way of business, always keep their stock in ice cellars, and fruit dealers preserve their ware fresh by similar means.

ALFA, OR ESPARTO GRASS.

The Government of Algeria having offered a prize for the best essay on the subject of Alfa (*Stipa tenacissima*), the award was made to one of the professors of the Medical College at Algiers. A summary of the contents of this essay is given in a recently issued report on the commerce and agriculture of Algeria for 1889, from which the following is gathered.

The Arabic word halfa, more commonly alfa, is applied to several plants of the genus *Stipa*, but the most important is *S. tenacissima*, which is found over a great extent of country in the south of Spain, Morocco, Algeria, Tunis, and Tripoli. Another species, *Stipa arenaria*, is found in Spain, and is principally used for the manufacture of coarse articles known as sparterie, such as baskets, cord, &c., and is much less esteemed than the Algerian species, which, indeed, is also exported from Spain.

The plant has a wide geographical range; the various places where it is grown have many features in common, but they also differ considerably in other respects. It grows from the sea-level up to an altitude of 1,800 metres. The only thing which seems fatal to it is marshy or undrained ground and persistent damp, especially when accompanied by cold. It delights in heat and drought sufficient to kill almost every other plant, and in undulating land where water cannot lodge. In Morocco it occupies an immense region, from the high plateaux, which are a continuation of those of Oran, almost as far as Tangier, but it is only gathered near Mogador. It is found in the south of Portugal, in a province more arid than the rest of the country—that of Algarve. In Spain it covers a large space on the plateaux, included within a triangle of which the three points are Malaga, Valencia, and Madrid. It abounds in the province of Murcia and Almeria. In Algeria it extends from the littoral of Oran to the Ksousr and the plateaux of the Oulad Sidi Checkh. In the department of Algiers it does not reach the littoral, nor does it occur in any region where the rainfall is, on an average, as much as 60 centimetres per annum. It covers a great part of the lower spur of Djebel Aurés, near Batna, but never spreads to the plains below.

The phases of vegetation of the alfa are as follows:—In the commencement of spring the old leaves enter on a period of activity, profiting by the first return of warm weather. The young leaves, which began to appear in autumn, are developed, burst forth, and the functions of vegetable life attain their maximum of intensity. About the end of April or the beginning of May the flowers appear, and by the middle of June the seeds are ripe. In July the plant enters a period of repose which lasts till the first rains of autumn, when it again enters into a period of activity.

The fecundation of the seed is very irregular. The stamens are rich in pollen and the ovaries are well developed, but many of the flowers seems absolutely sterile, and the seed vessels dry up without reaching maturity. The seed which does ripen is carried often to a great distance by the dry wind of summer, and commences to germinate after the first rains of autumn. It requires five or six years for the young plant to attain its normal height, and nearly fifteen before it can be plucked. But nature has a much more expeditious means of renewing the plant by rhizomes, which often travel a considerable distance in the sand and throw up new shoots, generally in a circular form round the old plant, each of which in time becomes a centre for still further propagation. The cultivation and artificial propagation of alfa has been attempted in Spain, but never in Africa.

Both in Spain and Algeria the period for gathering alfa is fixed by law, but both countries waited too long before introducing this salutary measure. In the latter country there is a close period from January 1st to June 30th, subject, however, to modification according to circumstances. In Morocco, Tunis, and Tripoli there is no restriction whatever.

The usual method of plucking the plant is by means of a stick 40 centimetres long, which the gatherer attaches to his left hand by a leather strap, he seizes with his right hand a packet of leaves, turns them round the stick, and pulls them out with both hands. He can thus gather from 30 to 40 kilos per hour.

Spaniards are far more adroit at this work than Arabs, and gather much more during the day, but they injure the plant more seriously than do the Arabs. The average amount that workmen can collect of green alfa is about as follows:—Spaniards, 300 to 400 kilos; Arabs, 150 to 200 kilos; women, or old men, 100 kilos; children, from 12 to 15 years, 35 to 40 kilos. The green alfa, when plucked, is placed upright in small bundles to dry, an operation which does not require more than from three to four days. The fibre loses from 18 to 40 per cent. of its weight during the operation. It is then transferred to depôts, where it is sorted and classed according to its length; the longest fibre is reserved for the manufacture of sparterie, the shorter is used for paper. In the English trade the various qualities are known by the terms good, fair, inferior, brush, and cord. The best qualities sometimes average about 50 per cent.; the fair may amount to 70 per cent.; and the worst quality to 20 per cent. The various kinds are then pressed by hydraulic machinery, bound with iron bands, and sent off to the port of shipment.

There is no doubt that during the past twenty years the quantity of alfa plants has been steadily decreasing, and in some places where it was formerly found there is no trace of it remaining. This is principally due to the custom of collecting it during the period of vegetation, and by unskilful manipulation of the plant.

The various countries which export alfa are:—Spain, where it has been in use for ages, the exportation from 1868 to 1872 amounted to 90,000 tons annually; now it is reduced to 45,000 tons. In Algeria the export commenced in 1863; in 1870, 33,000 tons were exported; the maximum, 110,000 tons, was attained in 1879; now it is about 80,000 tons. Tunisia exported 33,000 tons in 1879; now 100,000 tons are exported. Tripoli exported 80,000 tons in 1881; the production now may be stated at 75,000. Morocco only exports about 3,000 or 4,000 tons from Mogador. During the past few years the aggregate exportation of alfa from the before-mentioned countries has been increasing, whereas the demand for it has shown a tendency to decrease. From 1860 to 1869 the total exportation was not more than 95,000 tons; in 1876 this had nearly doubled; in 1881 it was 200,000 tons, and in 1887, 225,000 tons. The price has greatly decreased, and the time seems not to be far distant when it will not be profitable to gather it at all.

Every day wood-pulp is becoming more used, and employed with increased effect, not only in the manufacture of paper, but of various other substances formerly made chiefly from alfa. It is the manufacture of paper which consumes the greater part of the alfa exported from the countries which produce it. Thus, out of the 225,000 tons exported, 210,000 tons are said to be destined for that industry. The United Kingdom is the principal market, and takes 200,000 tons; the small remainder is purchased by France, Germany, and Belgium. The quantities sent to Italy, Austria, and Belgium are hardly appreciable.

RUSSIAN WOOL PRODUCTION.

The *Russie Commerciale* says that Russia owns nearly 50,000,000 ordinary sheep and 15,000,000 merinos. European Russia has 40,000,000, of which 38,000,000 are ordinary sheep and 2,000,000 merinos. The Caucasus has 12,000,000, of which 10,000,000 are ordinary sheep and 2,000,000 are merinos. Sheep are met with in nearly every province of Russia, with this difference, that they are far more numerous in the southern provinces than in those of the north. Owing to the immense stretches of pasture land, and to the temperate climate of the centre of Russia—which allows of flocks being kept in the fields nearly the whole of the year—the rearing of fine-woolled sheep predominates, particularly in the kingdom of Poland. In Taurida there are as many as 2,900,000 merinos; in the government of Ekaterinoslav, 1,900,000; in Kherson, 1,600,000; in Kuban, 1,300,000; in the government of Poltava, 500,000; in Saratow, 500,000; and in Kiev, Kharkoo, and Stavropol nearly 500,000 in each. There was a time—about 1860—when the rearing of fine-woolled sheep was in a high state of development, owing to the protectionist measures adopted by the Government, but since that period it has fallen off considerably. The construction of new railways has given a fresh impetus to land cultivation in the centre of Russia; the rents of land increased, while the prices of wool fell simultaneously under the influence of the competition of Australia, America, and the Cape of Good Hope. During the last few years the rearing of fine-woolled sheep has shown a tendency to increase in the southern part of the Caucasus, which is rich in pasturage. It may be asserted that it is Central Asia which in the future will become the centre of the Russian wool industry, owing to the enormous extent of land adapted to the rearing of sheep. The annual production of wool in Russia amounts to about 10,000,000 pouds (160,700 tons), which gives approximately 6 lbs. of wool for each sheep. The export of Russian wools is subject to considerable fluctuations each year. For example, in 1885, 21,000 tons were exported; in 1886, 24,550; and in 1888, 20,400 tons. The exporting ports are Rostov on the Don, Odessa, Riga, and Liban. The largest quantity is taken by England, but some is purchased by France, Germany, and Austria. If Russia exports wool she also imports it. During the year 1885, 10,060 tons were taken; in 1886, 8,830 tons; in 1887, 8,030 tons; and in 1888, 12,045 tons. Although the imports of wool only amount to half the quantity of the exports, in value they exceed them. For example, in 1887 the exports were valued at 16,000,000 roubles, and the imports at 17,000,000 roubles; in 1888 the exports did not reach 13,000,000 roubles, while the value of the imports exceeded 24,000,000 roubles. This is accounted for by the fact that Russia exports raw wools of inferior quality, whilst foreign countries send her wool of superior quality washed, spun, and dyed.

Obituary.

Sir Edwin Chadwick, K.C.B.—By the death, on Saturday morning last, 5th inst., of Sir Edwin Chadwick, the Society of Arts has lost one of its oldest and most energetic members. Sir Edwin was elected a member in 1847, and was in the same year chosen a Member of Council. He was also on the Council from 1868 to 1871, and a vice-president from 1872 to 1875, 1877 to 1880, and from 1884 to 1886. His first contribution to the *Journal* was printed in the fourth volume (1856), and is the report of an address delivered before the Philanthropic Congress at Brussels, on "Improvements in Machinery, and in Manufacturing Processes as affecting the Condition of the Labourer." In subsequent years he was instrumental in obtaining committees of the Society on drill in schools, the telegraphic system, conflagrations in London, street paving and drainage, &c., which committees produced useful reports that are printed in the *Journal*. In connection with the Drill Committee, a banner was presented by the Society of Arts to the London School Board, to be annually competed for by the schools under the Board. The pages of the *Journal* also contain many contributions from his pen on questions of sanitation, water supply, competitive examinations, physical training, &c. Sir Edwin Chadwick was born at Longsight, near Manchester, on the 24th January, 1800. He entered an attorney's office, but soon afterwards became a student at the Inner Temple. In due course he was called to the Bar. Before his official career commenced he was occupied in reporting and in literary work, and in the Westminster and London Reviews he discussed some of those questions to the elucidation of which he devoted his life, such as Insurance of Sickness by Friendly Societies (1828), Preventive Police Force (1829), and Removal of Stamp Duties on Newspapers and Taxes on Knowledge (1831). In 1832 he was appointed an Assistant Commissioner to inquire into the administration of relief in England and Wales, and afterwards he became a Commissioner. In 1833-34, as a Commissioner of Inquiry into the Employment of Children in Factories, he elaborated and extended the system of half-time school education. After the passing of the Poor-law Amendment Act in 1834, he was appointed Secretary of the Board which was formed by the Act. In 1841 he was engaged on an inquiry into the sanitary condition of the labouring population of Great Britain, and he produced his important report in 1842. He now became chief executive officer of the first General Board of Health. In 1854, the Board of Health was reconstructed, and Mr. Chadwick retired on a pension. He continued, however, to work with unabated vigour for the promulgation of his views on the various sanitary and economical questions of the day. He claimed to be the first to urge upon Government the purchase of the electric telegraphs, and the adoption of sixpenny telegrams. Mr. Chadwick was made a Companion of the Order of the Bath, in 1848; and in 1889, the further honour of Knight Commander of the Order was conferred upon him. On March 2, 1889, a public banquet was given to him in recognition of his life-long labours, and in honour of his having attained his 90th year.

Francis Bennoch.—Mr. Francis Bennoch, who had been a member of the Society of Arts since 1852, died suddenly on June 28th, at Kempen, in Rhenish Prussia, while on a business journey to Berlin. Mr. Bennoch was the son of a Dumfries-shire farmer, and came to London shortly before 1837, about which year he published a small volume of poems. This book he sent to the poet Wordsworth, who praised it, but advised the writer not to take to authorship as a profession. The advice was accepted, and Mr. Bennoch entered the silk trade, but he continued through life an interest in literary society, and numbered many distinguished men among his personal friends. He was an active member of the Council of the Silk Supply Association during the period of its existence. Of late years he has been director of several commercial companies and a member of the Council of Foreign Bondholders. Mr. Bennoch read before the Society of Arts a paper on "Thread or Fibre Gilding," on April 16th, 1856, and another on "Metropolitan Improvements and Thames Embankment," on April 29th, 1857. He also wrote one of a series of Reports on the London Exhibition of 1873, arranged by the Council of the Society of Arts, his subject being silk and velvet manufactures. He was a member of the Council 1856-57.

General Notes.

Paris Exhibition. — It is stated that the Diplomas and Complimentary Medals for British Exhibitors cannot be issued before the latter part of October next.

Shorthand Congress. — The Third International Shorthand Congress will take place this year from August 7th to 17th, in Munich, and the centenary of the birth of F. X. Gabelsberger, the founder of German shorthand, will be celebrated in connection with it. A gigantic bronze statue will be unveiled in honour of the inventor. There will also be an International Shorthand Exhibition.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Proceedings of the Society.

CANTOR LECTURES.

SOME CONSIDERATIONS CONCERNING COLOUR AND COLOURING.

By Prof. A. H. Church, M.A., F.R.S.

Lecture III.—Delivered March 31, 1890.

Syllabus.—Balance, Proportion, and Distribution of Colour—Interchange and Counterchange of Colour—Colours of some Natural and Artificial Materials—Decorative and Pictorial Colour—Colour in Relation to Architecture and Sculpture.

Distribution and Balance of Colour.—When the constituents of a set of colours to be associated together have been decided on, it still remains to determine their sequence and the relative areas they shall occupy. Such triads as were given in the last lecture may be made disagreeable or pleasant by altering their distribution or their proportions. The triad *red, gold, blue*, affords as good an illustration of this fact as we could wish. If we make the red and blue come into contact throughout the design in equal areas, and if we then spread over the surface a spray of gold foliage in such a way as to employ, in masses of considerable extent, just as much gold as red and as blue, the result will be crude and unsatisfactory. But we may develop the varied beauties of which this group is susceptible by modifying the arrangement and proportions of its constituents in scores of different ways. Let us devise one such way, of which the plan shall be—separation of the blue and red by gold, and the use of these three chromatic elements in the ratio 7 : 3 : 1 : so we make our blue ground cover 7-11ths of the area to be decorated; our arabesque and its curves, or our spray and its foliage, will be of red, 3-11ths, bordered throughout with gold, 1-11th. I need not tell you how much we may modify and improve the result by the beautiful curves of our spray, and by half entangling patches of the ground within its borders. And this end may be reached by many other methods which I cannot stay to describe.

One of the tetrads named in the last lecture will serve to illustrate these matters of arrangement and proportion. The example is taken from an early Irish illuminated missal. The four elements are silver, gold, red, and black. The proportionate areas are 4 : 4 : 1 : 1. Silver and gold quatrefoils alternate. They are bordered by red in the form of a line of uniform breadth; the residual space is covered with black, but this is broken up into such small portions that it does not look heavy, while the continuous red outline serves at once to bind the whole design together, and to prevent too strong a contrast of tone between the black and the gold or silver. You will be able to think of many an arrangement of these four elements which would prove less felicitous, and, doubtless, of others equally good.

I have before spoken of the principle of the "dominant hue." It will be easy to carry out this principle by modifying the area of the elements in our triads. In this way one of our "cold" triads—such as bluish-green, violet, red ochre, may be made "warm." In such a case we shall have to increase greatly the area occupied by the red ochre, and to proportionately diminish that of the other two elements of the group. We may, for instance, prepare a large design of foliage of red ochre upon a ground of bluish green, separating these two colours by a contour line of violet, adding perhaps some fine veins of violet to our large leaves. But it must be noted that such arrangements often become easier and more pleasing when we are at liberty to introduce a fourth element, even if that element be but white or other neutral. A fine old Rhodian tile in my collection affords a case in point. It has a ground of a red ochre hue occupying 5-10ths of the whole area. Upon this a design of white foliage, highly conventionalised, spreads in a connected and symmetrical fashion, and covers 3-10ths of the surface. The remaining 2-10ths are shared between a full blue and a slightly bluish green in nearly equal proportions. These colours are distributed upon the white portions of the design chiefly in the form of veinings. There is also a fifth but inconspicuous element in the chromatic scheme, namely, a delicate contour line of deep grey. The effect of the whole arrangement depends upon the dominant red hue of the ground, but this is refined and lightened by the net of white foliage, which, in its turn, gives strength and purity to the graceful curved forms of blue and of green which it encloses. The uses of colour-schemes, in which a dominant hue is present, are frequently of the utmost importance in hangings, papers, and wall-decorations. These have to perform the office of a background, and to set off one or more conspicuous chromatic elements in the room. If you want to display properly some fine pieces of blue and white porcelain, your walls must not be so coloured as to interfere with their effect, but rather to enhance it both as to tone and hue. A flat buff or grey may make your porcelain too conspicuous; a bright blue and a pure white will clash with it; a strong red will overpower it. A scheme of colouration, which in its totality produces the effect of a greyish olive green, half way in depth of tone between the white and the blue of your vases, will probably be found to answer well.

When it is not desired to direct attention specially to the colours of the objects in a room, then it is allowable to gather into certain parts of your wall decoration the more telling of the chromatic elements which enter into its composition. You accentuate the design by focussing the more saturated and luminous colours in the more important parts of the design.

From what I have stated thus far, I think it will be evident that, even if we could attain such a chromatic balance as would produce a true "neutralised bloom" on our walls, or in the carpets on our floors, we should still have left out of our scheme the more important chromatic elements belonging to our moveable furniture and ornaments. In fact, the system of contrasts of hue and tone—contrasts more or less subdued—is the only one by which a real unity of effect can be reached; at the same time that due prominence and relief are secured for those parts or objects where prominence and relief are needed.

Returning once more to our triads, I would mention a principle of arrangement often adopted with success, namely, the separation of two nearly related tones by a tone which is darker or lighter. Sometimes this sequence brings together chromatic elements which clash, and, of course, it must then be avoided. Still, the rivalry of two colours having the same degree of brightness is frequently unpleasant, especially where they are both strong. The triad of full red, gold, full blue, illustrates these observations. The use of a triad of three full colours is rarely successful, and can no more be tolerated than the presence of three trees of equal size and equal prominence in a landscape picture. Where three colours having three decidedly different tones are used in one scheme, we are almost compelled to arrange them in the order of their depth—dark, medium, light.

You will, I think, excuse the elementary and fragmentary character of all these remarks of mine on distribution and balance of colour; no one can be more conscious of their imperfection and of their commonplace character than I am.

Counterchange and Interchange. — In heraldic colouring the principle of counterchange is frequently adopted. Ermine is white spotted with black; counter-ermine, black spotted with white. Suppose a shield of arms divided diagonally from right to left, and bearing a star. Where the field is azure the star is argent, where the field is argent the other half of the star is azure. In the latter half of the 18th century the same arrangement was adopted in textiles and embroideries, great skill being shown in the passage from a design, say, of red upon a blue ground to the same design in blue upon a red ground. I have noticed that in the more successful of these counterchanged patterns the areas occupied by the pattern and the ground are about equal. When these designs were executed in "cut" work there was no loss of material, for the pattern cut out from one part of the design formed the ground of the next. In the cut-cloth-work of Resht in Persia, a similar mechanical method of procedure was adopted, but the counterchanges were not effected in the same piece.

The principle of interchange may be illustrated by the alteration of a set of tones of greenish yellow with a corresponding set of tones of violet. These tones may be so arranged that the series begins with the deepest tone of each colour alternated, the rest following in regular sequence, or the deepest tone of one colour may be followed by the lightest tone of the other, and so on; but a satisfactory effect is difficult of attainment.

Colours of Minerals.—I have time to refer to a very few only of the characteristics of coloured minerals. The colours of some of the most beautiful precious stones are in a measure dependent upon the phenomena of dichroism which they exhibit. The ruby, sapphire, emerald, and tourmaline may be named in this connection. Quite apart from the prismatic decomposition of light which these gems effect when facetted, they show, with more or less distinctiveness, the twin colours of dichroic bodies. The ruby exhibits in the same stone a pure red and a crimson or carmine-red; the sapphire a straw-yellow and a pure blue; the emerald a bluish-green and a pure green; and the tourmaline broken tints of yellowish-green and reddish-brown. No monochroic substance, such as paste, enamel, or glass, can give rise to the variable fluctuations of colour seen in these dichroic gems. The peculiar chatoyancy of Labrador spar has also not yet been imitated in any artificial material. The beauty of lapis-lazuli and of many agates and jaspers is no doubt partly dependent upon the pulsing of the colours they exhibit, partly upon a certain measure of translucency which they possess. This quality of trauslucency is also seen in many marbles, especially when they are polished; its absence from some artificial materials (such as terra-cotta) is perhaps one of the reasons why it is difficult to associate the two classes of materials together with satisfactory effect. When both are in small pieces, and especially when they all receive together the same polish, the incongruity in question does not attract notice. The tesselated Roman pavements found in this country often afford excellent illustrations of this harmonising of natural with artificial materials—marble and stone, with pottery and even glass.

The picturesque coloured markings and veinings of many marbles are best developed by polishing, and best seen in surfaces of considerable size. If these surfaces are not plane, their curvature should not be complicated with flutings or other sculptured treatment. A carved ornament in such marble is a mistake, at least whenever the coloured markings are decided. Man's art in relief spoils nature's decoration in colour. For this reason the carved work in Derbyshire alabaster, for which the late Sir Gilbert Scott showed so much partiality (witness many a reredos which he designed) is most unsatisfactory. Over and over again a dark veining makes a prominent part of the carving appear to recede, while a bright and pale patch throws a hollow or recessed detail into conspicuous relief.

Colours of Animals.—The most brilliantly coloured of animals—birds—naturally attract our attention. I do not pretend to champion all the chromatic arrangements of nature. Yet two circumstances must be taken into account in considering the colours of animals and plants. These colours and colour-associations must not be considered apart from their natural *entourage* and the conditions of their existence. And, secondly, if we are to follow the leadings of evolutionists, it cannot be maintained that the colouration of plants and animals in a state of nature is connected with the chromatic tastes of man. Of course, under domestication, the hues of both are greatly modified by processes of artificial selection and of treatment.

Let me direct your attention to the colours of certain humming birds as typical examples of peculiarly powerful colours, many of them belonging, in the intensity of their regular refraction of light, to the metallic group, but being more strongly coloured. One of these is a Central American species, and is known as the "garnet" *(Lamprolæma Rhami)*. It is commonly spoken of as showing a brilliant patch of garnet-red upon its throat and breast. But in reality this hue is not invariable and uniform. In the constant movements of the living bird it must be ever changing with its changes of position. As you examine a mounted specimen you will see at first only a metallic crimson; but when your view-point is altered, all the passage-tints between a rose-madder and a greenish yellow follow in their regular spectral sequence. This sequence, which will be observed, I believe, in all similar cases, is connected with the mode of production of these metallic colours. They do not arise directly from the presence of actual colouring matters or pigments, but from the minute optical structure of the web. Another humming bird, a "train-bearer" *(Cynanthus forficatus)*, has its conspicuous tail-feathers adorned with metallic violet; but this violet passes in some positions and in some parts into a splendid greenish blue, every intermediate tint being present. So with one of the "comets" *(Sappho sparganurus)*, the tail-feathers sparkle with a golden bronze, ranging from orange to red-orange. Another "comet" *(Sappho phaon)*, is similarly decorated, but the colours range from madder-red to red-purple. Another bird, the "ruby and topaz" *(Chrysolampis mosquitus)*, has on its head a patch of metallic crimson, passing into orange when viewed from some positions; similarly, the fiery metallic range of its breast passes into yellowish green in some portions.

I cannot refrain from citing the case of another humming-bird, one of the "sapphires" (*Eucephala cœrulea*). Here the head is decorated with a colour not of the metallic order, but still very rich, almost the colour of French ultramarine blue. But on the breast of this bird a metallic colour re-appears; it is a fine blue, passing into an equally fine green. I have said nothing of the brownish-black background which shows off all these splendid hues, because I want you to notice more particularly that these dazzling metallic colours are never really uniform and flat, even though their tones may be equivalent, for they show large ranges of hue, not capricious, but following the orderly sequence of wave-lengths in the spectrum. I must omit all reference to the colouring of butterflies and shells, about which I had much to say, in order to pass on to the vegetable kingdom.

Colours of Plants.—The texture and translucency of flowers and leaves greatly modify the hues of the colouring matter they contain, and of the light which they reflect. The peculiar glistening of the cell walls in the coloured tissues of flowers is a case in point; it is sometimes erroneously spoken of as crystalline. The distribution of the various colouring matters of flowers in the cells, when the coloured tissues are examined under the microscope, is seen to be much less regular than might be imagined, and is doubtless one of the causes of the peculiar chromatic beauty of many flowers. In speaking of the colours of plants some reference must be made to the green of foliage. If the fully developed leaves of a forest tree in summer sometimes tend towards a certain heaviness and monotony of hue, still there is, even in this case, a degree of variety present. Some leaves are in shadow, some transmit the incident light, some reflect the blue of the sky or the grey of clouds, some display in perfection their local colour, and some show in different parts the various hues just indicated. And then, too, it must not be forgotten that the green colour of foliage varies with its age, and that it always possesses a singular characteristic which distinguishes it from other greens; for if we place a spray of green leaves upon a piece of green cloth or of green paper resembling it in general hue, we shall yet find that the natural pigment differs materially from the artificial in its chromatic constituents. To prove this you need not have recourse to prismatic analysis; you have only to illuminate both surfaces with red light, or to inspect both through a piece of red glass, to see a very striking difference, especially noticeable with the yellowish-green foliage of young branches.

I regret that time fails me, or I should have liked to direct your attention to the colours and textures of wood, and of various vegetable fibres.

Colours of Artificial Materials and of Fabrics.—I have already named glass as affording illustrations of the throbbing or vibrating of colour. In the examples of coloured glass which I now show you by means of the electric lantern, we may observe the various causes which conspire to produce the artistic charm of really beautiful glass. They include not merely fluctuations in hue and tone, but the presence of bubbles and blebs, of striæ, and of solid and comparatively opaque particles. All these things serve to prevent the direct emergence of uniformly-coloured beams of light from the material. I have mounted some of these specimens of glass in pairs, putting side by side, for instance, a piece of builders' blue glass and a piece of the beautiful blue glass made by Messrs. Rust and Co., of 353, Battersea-park-road, S.W., to whom, indeed, I am indebted for a series of choice specimens, illustrating the poetry of coloured glass as distinguished from its most ordinary prose. In this connection, it is interesting to observe that the good old stained glass, like these fine samples of Messrs. Rust and Co.'s manufacture, is immediately discriminated from the common-place kinds in a strong light. When the sun or the electric light shines through the former it becomes itself illuminated, but throws no definite coloured images upon a white screen suitably placed; while the optically perfect but wholly uninteresting flat-coloured modern glass reproduces by transmission its chromatic design. By this test the modern "restorations" in an ancient window may frequently be recognised.

I have no time to tell of the colours of other artificial products, of enamels and of porcelain, for example. But I cannot refrain from directing your attention to the colours and patinas of certain metallic alloys. The Japanese are masters in this particular line. Their *shibuichi*, or grey bronze, consisting of copper alloyed with considerable but varying proportions of silver, gives a series of yellowish greys; their *shakudo*, copper containing a small per-centage of gold, when heated in suitable pickling baths, is susceptible of receiving a blackish patina, sometimes violet-black, sometimes bluish-black. Their bronzes, into which lead and antimony, as well as tin, often enter, frequently present very beautiful effects of colour upon their surface. But perhaps the "red copper" of the Japanese metal-worker is as beautiful as any alloy. It is pure copper, the surface of which has become coated with a strongly adherent and coherent film of red sub oxide. This film is tough and strong, and varies in colour in different specimens from a crimson-red to a reddish brown. This patina is often translucent, if not transparent, and shows a fine gloss like that of lacquer. Messrs. Christophle, of Paris, and Messrs. Tiffany, of New York, have achieved a measure of success in their attempts to reproduce some of these beautiful Japanese patinas, but there remains a large field for their employment in artistic metal-work, in the form of flat inlays and reliefs.

I cannot do better, in order to illustrate the tone and colour effects which may be produced by the association of different textile fibres, than show you in the light of the electric lantern a series of Japanese brocades and of Persian embroideries. The "shot" silks, the varying sheen produced by the different directions of the threads, and the association of lustrous with comparatively dull materials—all conduce to the beauty of the effects.

Pictorial and Decorative Art.—It has often been pointed out that colour is an end in decorative art, a means in pictorial. This almost amounts to saying that decorative colour is without meaning; expresses neither the ideal nor the real. I cannot but think that this view is far from being correct. Let us contrast and compare the colouring of a landscape and that of a decorative fabric. In the picture great use is made of gradation of tone and hue, in order to represent atmosphere, the play of light and shade, and different planes; the artist, moreover, is restrained in his use of full and saturated colours, nor does he attempt to represent all he sees, but makes such a selection of the materials at his disposal as, without violating nature, shall best serve to realise his impression of the scene. Form is with him of equal importance with colour, while symmetrical arrangement and repetition of similar elements are never made evidently conspicuous. The designer of a fabric, one, say, for use as a curtain, avoids the use of those contrivances by which the flatness of the surface would be destroyed; gradation of hue and tone, though admissible, plays a quite subordinate part in his work. He is at liberty to use the most saturated and intense colours, provided only he can so employ them as to produce a pleasing harmony, and at the same time be in accord with the nature of his material and the purpose to which his design is to be put. Moreover, the decorator selects, as does the landscape painter, but he rejects much more than he absorbs. To nature he goes for motives, but individualisation assumes the last place, generalisation the first. Form and colour are not with the decorator of equal moment, sometimes the former being paramount, sometimes the latter. Usually, the less pronounced his colour the more dependence does he place upon his form, although in complex chromatic schemes also he has often to rely greatly upon trenchant contours in order to avoid confusion. The notion that bad or weak drawing is permissible in decorative art ought not to be accepted for one moment. The very fact that the boundaries between two colours in ornamental designs frequently need to be sharply accentuated by means of well-defined outlines should suffice to demonstrate the necessity of thorough draughtsmanship. And, lastly, the decorator makes large and frequent use of symmetrical and repetitive arrangements.

If I am right in this comparison and contrast, then the distinction between decorative and pictorial work is, like many another distinction in the domain of art, one of degree rather than of kind, quantitative rather than qualitative. The same elements are at the disposal of the decorative and of the pictorial artist, but they must be employed in different proportions. And here I am in accord with the view that there are an infinite number of possible transitions between the colouring that is most fully pictorial and picturesque, and the colouring that is most purely decorative or conventional. Much, but by no means all, of Japanese decorative work in colour illustrates some of these transitional forms.

Colour in Relation to Sculpture.—In the very few words on this subject for which I can find time I should wish to draw your attention to these two points, namely, the surroundings of sculpture in relation to its colour, and the material of sculpture in relation to its colour. It seems to me that when sculpture is destined to form an integral part of an architectural scheme, its tone and its hue must not be such as to interfere with the unity of the plan, but rather to enrich and vary it. And it may easily happen that an association of sculpture in marble with an edifice in stone may be harmonious when both marble and stone are fresh, but may in course of time accord less happily, as the latter darkens with age much more considerably than the former. The same effect is produced when a glaring white marble monument is intruded into a building deeply toned with the rich warm grey of centuries. So, on the other hand, a statue in bronze may be too deep in tone to harmonise with new clean cut stone, but, as years pass, the startling difference between them will abate. The case is different where the building and the sculpture it contains are not intended to fuse into one organic whole. Under such circumstances, the building must be subordinated to and even contrasted with its contents; it becomes a background so coloured and so arranged as to emphasise the statuary it protects; and in considering the vexed question of the artificial colouring of works in sculpture, it will be well to glance for a moment at the four chief kinds of material out of which such sculpture is generally wrought. These materials are terra-cotta, bronze, stone, and white marble. It will be owned that the critical eye accepts without hesitation the refined colouring which the exquisite terra-cotta figures from Tanagra still so frequently retain, as well as the varied hues of the patina on statues in bronze. In the latter case, we go so far as to dislike what may be called the natural hue of the metal, unless it appears to a limited extent only in such parts of a figure as *might* be supposed to have lost their artificial or altered surface colour by a process of attrition. But when we leave artificial materials and pass on to those which are natural our attitude as to the problem of colouring differs. While there seems to be an innate congruity between artificial materials and artificial colouring, natural materials lend themselves less readily to chromatic treatment. Perhaps there are here two causes at work, one being our satisfaction with and appreciation of the natural beauty of the tones and hues of native substances, the other being the difficulty of bringing our added colouration into harmony with that which is natural. This view is supported by the observation that the addition of colour to the rarer and choicer materials, such as statuary marble, is more generally resented than the similar treatment of the commoner and less interesting kinds of stone. But is there not a third and more potent cause? Does not pure white marble, with its slight translucency and its beautiful crystalline texture, lend itself so perfectly to the presentation of ideal forms that even the faintest suggestion of realistic colour may look like sacrilege, and may only too easily lapse into vulgarity?

In architecture, too, the poorer and less interesting the material, the more useful does the addition of artificial colour become. Yet it may serve, on the one hand, to emphasise the poverty and weakness of bad contours and mouldings, though, on the other hand, it may be made to accentuate and to ennoble forms which are in themselves beautiful. Its distribution and arrangement are as important as its tone and hue. It may destroy the unity of an architectural scheme, or it may serve to fuse discordant or fragmentary elements into one harmonious whole.

Excuse, ladies and gentlemen, the all too casual and imperfect discourses which I now conclude. Yet I trust my disjointed utterances may not prove to be wholly valueless, for they may serve, if no other end, that of directing your attention and guiding your observation to some of the infinite resources and intricate delights of chromatic combinations. I venture, moreover, to express my confidence that the scientific study of the glorious sheaf of spectral colours which we have been making together will not lead you to agree with the poet Keats when he sang—

> "Do not all charms fly
> At the mere touch of cold philosophy?
> There was an awful rainbow once in heaven:
> We know her woof, her texture—she is given
> In the dull catalogue of common things."

Miscellaneous.

TRADE IN INDIAN DYES AND TANS.*

It may be pointed out that in some of the returns of the foreign trade of India the dye-stuffs are not separately recorded from the tans, so that they have to be dealt with collectively. There is, however, no tan-stuff, either imported or exported, that is of any great importance, for it would be difficult to determine how far the returns of cutch could be assigned to dyes or to tans, and cutch is the most important tan that is exported from India.

The influence of the modern trade in aniline dyes has been widespread and most destructive of the indigenous industries. These cheap colours have not only largely depraved the tastes of the people, but have demoralised their industries. The soft delicacy and harmony of colour which formerly characterised the Indian fabrics, have to an appalling extent given place to the brilliant and staring hues of the coal-tar dyes, and coincident with this degeneration, the reputation for durability formerly enjoyed by the Indian dyed fabrics has been all but effaced. The Indian textile industries have been thus irreparably injured, and at the same time many of the indigenous tinctorial secrets have been lost to the dyers' craft, so that a revival may to some extent be impossible. This decline may be briefly demonstrated by the figures of foreign trade (exports and imports) in dye-stuffs. In 1873-74, for example, the exports of safflower from India were valued at Rs. 7,58,906; last year (1887-88) they were only Rs. 76,616. Lac-dye to the extent of Rs. 4,45,481 was exported from India in 1873-74, but last year (1887-88) the exports had fallen off to Rs. 6,205. During the Colonial and Indian Exhibition, the writer was informed by a merchant that so completely had the lac-dye trade been destroyed by aniline, that a large quantity of lac-dye was recently thrown into the Thames as worthless and unsaleable. Pursuing this line of reasoning still further, examples of the opposite character, namely, the decline in the trade of imported dyes, may now be given. India obtained cochineal in 1880-81 to the value of Rs. 6,99,354, the year following the imports were little more than half that amount, and in 1883-84 they were valued at Rs. 1,73,531; but a slight revival seems to have set in, for the imports had attained in 1887-88 to the value of Rs. 2,27,545. Of the dye-stuffs of India, indigo appears to have been least affected by this assumed common cause of depression in the indigenous dye-trade. But even indigo would appear to be giving indications of a decline. The exports in 1883-84 were valued at Rs. 4,64,09,906; in 1884-85 at Rs. 4,06,88,996; in 1885-86 at Rs. 3,78,31,601; in 1886-87 at Rs. 3,69,16,769; in 1887-88 at Rs. 3,89,06,494. Turning now in search of an explanation for these facts to the returns of the trade in aniline dyes, these were valued in 1875-76 at Rs. 3,87,850; in 1879-80 at Rs. 5,90,791; in 1880-81 at Rs. 7,68,221; in 1881-82 at Rs. 6,00,208; in 1883-84 at Rs. 11,03,240; in 1884-85 at Rs. 10,43,949; in 1885-86 at Rs. 9,17,841; in 1886-87 at Rs. 10,08,034; and in 1887-88 at Rs. 10,31,972. There is thus an import trade of 10 lakhs of rupees worth of aniline dyes which ten or fifteen years ago had no existence, and this new trade, as nearly as possible, corresponds to the decline in other dye-stuffs.

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* Abstracted from some "Notes on Indian Economic Products:" being selections from the records of the Government of India, Revenue and Agricultural Department, by the Reporter on Economic Products, Dr. George Watt.

The assumption would thus seem justifiable that the falling off in the demand for Indian tinctorial materials has its counterpart in the remarkable growth of the aniline trade. At the same time, there are certain other striking features of the Indian dye-trade. It has been stated that England and France obtained their knowledge of Turkey-red dyeing from India. They thus learned two important facts: (*a*) the art of using oil as a mordant, and (*b*) the property of a European wild plant, madder, in yielding by this process a brilliant red dye. It might naturally have been expected that the country from which so valuable a secret was obtained would, at least for some time, have continued to participate in the trade. Far from this having been the case, the European and Persian cultivated madder seems rapidly to have displaced the wild product obtained from this country. India, in fact, early began to import madder dye, and in 1876-77 obtained (mainly from Persia) that root to the value of Rs. 1,01,163. From that date the imports fluctuated, but in 1883-84 they attained the by no means inconsiderable amount of Rs. 3,92,809. But since 1883-84 they have steadily declined, and in 1887-88 were valued at only Rs. 1,86,429. It would thus seem that the coal-tar alizarin, has begun in India, as it has in Europe, to displace the vegetable madder. But that India should even have ever imported any madder is a reflection on the Indian want of energy in utilising the immense supply that for ages had been allowed to waste on the mountain sides. In the same way, while saffron is an abundant wild plant in Kashmir, India, in 1883-84, imported that dye and medicine to the value of Rs. 5,97,910, and the trade in it seems fairly stationary, for last year (1887-88), the imports amounted to Rs. 5,80,580 in value.

The total trade in Indian dyes and tans may be here summarised, the values in every fifth year after 1872-73 being shown. It may be explained that since 1883-84 the returns of dyes and tans are made to include cutch—a dyeing and tanning material previous to that date shown under gums and resins. This fact would render comparison with past years' trade fallacious, for while, as shown above, the trade in most dye-stuffs has declined, that in cutch has steadily improved for many years past. Thus, for example, the comparison of the returns of exports of dye-stuffs for 1882-83 with those of 1883-84 would involve an error of Rs. 30,52,434—the value of the cutch exported in the former year, but not returned under dyes and tans. To allow of exact comparison the following Table has been made to include cutch:—

Years.	Imports.	Exports.		Total.
		Indian Produce.	Foreign Produce.	
	Rs.	Rs.	Rs.	Rs.
1872-73	19,64,857	3,87,46,335	1,42,422	4,08,53,614
1877-78	14,75,065	4,05,47,416	95,318	4,21,17,799
1882-83	23,58,291	4,46,66,707	1,03,941	4,71,28,939
1887-88	38,14,551	4,68,30,475	1,42,857	5,07,87,893

It will be observed that in the column of exports the writer has recorded the amounts of foreign produce included under imports which were afterwards exported to foreign countries. The grand totals are, therefore, the complete foreign commercial transactions, since the importer of a product may be a perfectly distinct person from the exporter. By deducting the amounts of foreign produce exported from the total imports, the actual amounts of foreign dye-stuffs used up in India itself are obtained for each of the above years. It may, in conclusion, be repeated that the decline in the exports of Indian dye-stuffs which it has been maintained has been coincident with the growth of the import trade in aniline dye, does not appear from the grand totals of the Indian dye trade, because of its being more than balanced by the increase in the exports of cutch. The uses of that substance, both as a dye and a tan, are being almost daily extended, and during the past seventeen years the exports have increased by 229 per cent. in value, and 160 per cent. in quantity.

NATIVE PERUVIAN COTTON.

The United States Consular Agent at Payta says, that after five years of drought, the province and State of Payta are naturally depressed in the way of commerce and all kinds of industry. The valley of Chira forms a favourable exception. The production of the valley consists principally of native Peruvian cotton (*Gossypium herbaceum peruvianum*), an article used very extensively in Europe for the manufacture of woollen goods, with which it mixes readily, on account of its rough, strong, and long fibre, is produced abundantly throughout the State after the rainy seasons, which are periodical, and occur generally every seven years, and is cultivated always along the banks of rivers on lowlands irrigated by the overflow of streams. The plant is arborescent and perennial, and after fully developing continues producing cotton for five or six years in succession, provided there be some moisture in the ground, needing, however, very little of it on account of its deep rooting, thus reaching moisture at great depths. The system of cultivation of this plant is quite primitive, the seeds being planted by making holes in the ground with spades, without tilling or manuring the soil. The plant becomes developed and begins to bear cotton in dry and sandy soil about six months after planting, and about nine months in rich and wet land, continuing to yield at short intervals for five or six more years in succession. The plant may be observed in blossom, with pods, buds, and cotton all at the same time, and giving a continual yield for the time above stated. In certain seasons of the year, about every seven years, the rains are incessant for about two months, both in the interior and on the coast, and water descends in such abundance as almost to inundate the country. Large torrents stream down the mountain side, the valley of the Chira is deluged, flat lands within it are turned into morasses, and morasses into lakes; in fact, the lowland becomes submerged, and the accumulated mass of waters rush with great force down the central valley, which forms their only outlet. The valley, however, is wide, and the descent very gradual. The extent of the valley through which the water flows is from three to four miles wide, and although it is nearly 200 miles in extent, the valley for the whole distance is almost level. The rains generally cease in March, but it requires from thirty-five to fifty days for the water to disappear and leave the land dry. As soon as that is effected there springs up, from the whole surface of the ground which has been thus submerged, most luxuriant vegetation. The soil is wonderfully rich, and has been under cultivation by the aborigines from time immemorial, and its fertility is kept up unimpaired by the slime which is abundantly deposited during inundation. The cotton is collected, when the pods open, by women and children, who are paid in proportion to the quantity collected, the prevailing rates being about 1s. 8d. for every 100 pounds. It is taken from the fields to the ginning house, where it is cleaned and made up into bales of about 175 pounds each. There are five of such establishments in the province of Payta, one in Querecotillo, on the east side of the river, owned by an Englishman; two in Sullana, a city of about 4,000 inhabitants, on the west side of the river, owned by natives; two at La Huaca, owned by an Englishman and an Italian. A considerable quantity of cotton is annually exported, and seeds are now also exported for oil making. Europe is the market for both products.

SOCIAL AND ECONOMIC CONDITION OF SPAIN.

M. Maurice Harbulot, writing in the *Journal de la Société de Statistique de Paris*, calls attention to the recent issue, by the Geographical and Statistical Institute of Spain, of a publication entitled, *Resena geographica y estadistica de Espana*, which, he says, is a veritable geographical and statistical encyclopædia of the Iberian peninsula. In it are found tables relating to the population, education, army and navy, criminal and civil justice, prisons, finances, commerce and navigation, banks, commercial societies, elections, public assistance, sanitary condition, and matters affecting the colonies. From this volume it appears that the first census in Spain was taken in 1768. Before this period only vague indications were given of the number of the inhabitants, which the author of the *Histoire philosophique du commerce des deux Indes* placed at 7,423,590 in the year 1747, and which was given as 5,700,000 only by another authority, Don Geronimo de Ustaritz, in his *Théorie du Commerce*. In 1768, a census by diocese was ordered by the Government, and the result showed a total population of 9,159,999 souls. In 1787, there was another enumeration, at which the numbers were fixed at 10,268,150, or 1,108,151 more than in 1768. In the year 1877, when the last census was taken, Spain had a population of 16,634,345, including the inhabitants of the adjacent islands and the North African possessions, and if the colonies were taken into account, the number would be increased to 24,456,468. The movement of the population in 1884 may be summarised as follows:—Births, 637,052; marriages, 115,470; and deaths, 535,256. The birth-rate in Spain is 36·6 per 1,000 inhabitants; higher by 11 per 1,000 than that of France, and the death-rate is 31 per 1,000. The excess of births over deaths in 1884 was, therefore, 101,796, and the increase of the population in Spain, in that year, was in the proportion of ·59 per cent. As regards statistics of emigration and immigration, it is only since the year 1882 that official returns on this subject have been prepared. According to the latest returns, the number of Spaniards residing abroad, in 1884, amounted to 332,485, of whom 75,794 were in Europe, 420 in Asia, 115,449 in Africa, and 140,822 in America. The permanent army of the Peninsula consists of 93,287 men, besides 13,758 officers. To these numbers must be added those of the civic guard, and the *gendarmerie*, as follows:—Civic guard, 15,216 men, and 802 officers; *gendarmerie*, 14,200 men, and 665 officers. The strength of the Spanish navy has varied very considerably from time to time, and in the history of the country it will be found that it was greatest during the reign of Philip V., and in the year 1785. In the latter year, the navy consisted of 95 ships of the line, 56 frigates, and 31 sloops, making a total of 182 vessels. At the present time, the navy consists of 151 vessels, manned by 14,231 sailors, with 2,788 officers. Coming next to the question of civil and criminal justice, it appears that in 1885 the number of crimes and offences recorded amounted to 20,628; 29,029 persons were prosecuted, of whom 8,476 were acquitted, and the remainder were sentenced to various terms of imprisonment and fines. During the same year 83,278 persons were brought before the various Spanish tribunals accused of misdemeanours, 19,885 of whom were acquitted, and 63,393 convicted. The proportion between the number of acquittals and the number of accused varied between 29·20 per cent. in the case of crimes and offences, and 23·88 per cent. for simple infractions of the law. The number of suicides in Spain during the period 1881-1884 was 2,422, or an annual average of 605; in 1859-1862 the average was only 223, that is, nearly three times lower than the present average. In spite of this augmentation, Spain still remains the lowest on the list of European countries as regards the proportion of suicides to the total population, the actual ratio being 4·11 per 100,000. Public instruction in Spain is given in primary schools, middle-class schools, universities, and special civil schools. The number of public and private elementary schools, which in 1850 was only 17,434, has since increased in very considerable proportions. In 1880 it amounted to 29,828 establishments, 23,132 public and 6,696 private. Secondary education is conducted in "institutions," or middle-class schools, somewhat like universities in their organisation, and the expenses are provided by the province or commune in which the institution is situated. Only the Cardinal Cisneros and the Saint Isidore institutions are supported by the State. The law has rendered obligatory the establishment of an institution in each province, and in some provinces there are several. In 1879 there were 61 of these institutions throughout the country. In addition there are 356 colleges, which brings the number of establishments in which secondary education is afforded to 417. It is the Government which supports the expenses of university education, properly so called. All of these universities possess a faculty of law, and all equally, with the exception of Oviedo, a faculty of medicine. Madrid, Barcelona, Grenada, and Santiago have a school of pharmacy; Madrid, Barcelona, and Salamanca, a faculty of science; and Madrid, Barcelona, Grenada, Salamanca, Seville, and Saragossa, a faculty of philosophy and letters. Government also supports various special schools—engineering, mining, agriculture, architecture, fine arts, music, diplomacy, commerce, &c. In the matter of public works, Spain, in 1883, had 304 ports, of which 54 had been constructed during the period 1881-83. The coasts are lighted by 205 lighthouses. There were 6,491,870 metres of national roads of the first-class, 7,777,863 metres of the second-class, and 8,947,335 metres of the third-class, making a total length of 23,217,068 metres, or 47,370,418 if the roads projected and in course of construction were included. There is no very considerable development of railways, only 8,681,055 metres, or 5,390 miles, being open for traffic, while the length of tramways amounted to 107,150 metres, or 66 miles. There were 2,801 post-offices in the kingdom in 1884, while the length of telegraph wires amounted in the same year to 17,488 kilometres, or 10,860 miles. The telephone is at work in Madrid, Barcelona, and Valence, and during the first half of 1885 the receipts from the latter amounted to £1,161. As regards the mining industries of the country, Spain is divided into three sections, and twelve mining districts. At the head of each section there is appointed an inspector-general of the first-class; at the head of each district an inspector-general of the second-class. Finally, there is a chief mining engineer for each province. In 1886, the latest year for which mining statistics are available, there were 2,276 mines in operation, employing 50,841 men, 2,086 women, and 8,209 children, in all 62,936 persons. For the extraction and working of the various products 555 steam-engines were employed, representing 13,884 horse-power. The value of the total mining production amounted to £4,325,160. The number of accidents that happened in mines during the year was 1,260, a proportion of 3·5 per cent. of the workpeople employed. Of this number 112 persons were killed and 430 severely injured. The number of iron mines in operation was 526, employing 13,682 workmen, who produced 4,166,946 tons of ore. The official value of this quantity was 14,247,509 pesetas, or £569,900. The quantity of lead ore produced amounted to 342,200 tons, from 814 mines, worked by 17,690 persons, the value of this product being £1,711,240. The copper ore mines numbered 42, and the number of workpeople employed 10,566. The quantity produced amounted to 2,376,381 tons, valued at £1,054,688. As regards coal, although Spanish soil is not very rich in combustibles, it is found in some considerable quantities. For example, anthracite is found in Gerona, Lerida, Santander, Asturias, Leon Palencia, Burgos, Guadalajara, Cuenca, Ciudad Real, Badajoz, Cordoba, and Seville. The most important coal basins are those of San Juan de las Abadesas (Gerona), Mieres (Asturias), Barruelo and Orbo (Palencia), Puertollano (Ciudad Real), Belmez and Espiel (Cordoba), and Villanueva del Rio (Seville). Lignite is present in the chalky soil of Fernel in great quantity, and also in Santander, Guipazcoa, Huesca, Lerida, Barcelona, Castellon, Cuenca, Guadalajara, and Galicia. The number of anthracite coal mines in 1886 amounted to 502, and the workpeople engaged in them to 9,309. The production was 977,559 tons (an increase of 58,119 tons over the previous year), valued at 8,186,674 pesetas, or £327,467. The number of lignite coal mines was 54, number of men employed 497, and the production 23,873 tons, valued at 395,119 pesetas, or £15,804. The forty-five provinces of Spain are far from having the same commercial and industrial importance, as a comparison shows that Madrid is far in advance as regards her industry and commerce, this province being nearly approached by Barcelona. Seville, Valencia, and Cadiz come next, while Soria and the Canary isles close the list. The principal fisheries of Spain are the sardine and the lobster. In 1881 the sardine fisheries yielded 1,673,761,000 fish, valued at £416,000. This figure is a little higher than the average of the preceding five years, while 45,643 lobsters were taken in 1885, during the period specially reserved for this fishery. The value of the other fish taken amounted to £307,736. The revenue of the kingdom is raised by a system of direct and indirect taxation, stamp duties, Government monopolies, and income from State property. From the principal resources of the country the sum of £29,000,000 was raised in 1883, chiefly made up as follows:—Land tax, £6,596,000; industrial and commercial tax, £1,332,000; consumption tax, taxes on mines, registration, transmission of property, &c., £6,256,000; Customs, £4,936,000; State lotteries, £3,124,000; tobacco, £5,192,000. Coming next to the question of the trade and navigation, it appears from the *Resena* that the value of the imports into Spain, which only amounted in 1864 to £19,000,000 sterling, and the exports to £14,000,000, increased in 1884 to £31,000,000 and £25,000,000 respectively. As regards the shipping, there were in the latter year 15,041 vessels engaged in the over sea trade, with a tonnage of 7,255,000, entering the various ports of kingdom, while the clearances numbered 14,873 and the tonnage 9,690,211. During the same year 42,828 vessels engaged in the coasting trade entered, and 42,631 cleared.

THE PUBLIC CHARITIES OF FRANCE.

A report has recently been made by M. Henri Monod, Director of Assistance and Public Hygiène in France, to the Minister of the Interior. The data are only completed so as to include the year 1885, and the report is stated to contain the most perfect record of statistics ever compiled on the subject of French charity. Public charity is defined by M. Monod as "the money which is contributed by the public, and which is employed to relieve the poor;" and the United States Consul at Limoges, in a notice of the report, says that the sums for public charity comprehend—outside of the expenses for public charity—those which are paid by means of public contributions, and are used to relieve private works; they are necessarily charged on the budget either of the State, department, commune, or the public institutions which are national institutions—hospitals, almshouses, bureaux of charity, and public charities of Paris. The contributions of individual charity which are not paid out of the public treasury, the expenses of private works of benevolence, though generally recognised for the public good, are not comprised in the following statistics. The total amount given in public charity in France during the year 1885 was 184,121,099 francs, or £7,364,844. The State, the departments, and the communes, altogether, by means of taxes levied, raised of this sum £3,569,684, or a little more than 48 per cent. of the whole amount. As the census of 1886 gave to France a population of 38,218,903 inhabitants, this would represent 22·3d. per head. The deficiency of £3,795,168, or about 52 per cent. of the whole, has been made up by the individual resources of the public institutions, and the income from the different endowments, which, added to the £3,569,684, gives the sum total as above. In Paris the amount raised in 1885 was £2,030,916; the amount actually given by the taxpayers was £1,270,128, and from other resources £760,788. As the population of Paris, as given in 1886, was 2,344,550, this would be about 10s. 9d. per head. In France, outside of Paris, the amount expended in public charity reached £5,333,932, made up as follows:—Amount paid with the resources of the public establishments and the income from endowment funds, £3,034,372; money paid by the taxpayers, £2,299,556, or 15·3d. per head. Consul Griffin remarks that it is strange to notice a striking coincidence here between the rate per head for Paris and that for London; in Paris it was 10s. 9d. per head, while in London it was 10s. 10d. Outside of these two cities, however, the difference is very marked, the average rate per head for the whole of France being only 1s. 3d., while in England it is 5s. 5d. There exists in France a general organisation of public help for the purpose only of assisting children and the insane. The other objects of charity appear to be given over to the chance of goodwill. For the rural population, which has about 35,712 communes, with a total of 27,557,630 inhabitants, the average of expenses for communal charity is 3·6d. per head, and after deducting the expenses that are obligatory, and which are applied to assist children and the insane, this tax is reduced to 2·6d. per head. Out of the £7,360,000 contributed in France for the public charities, the budget of the Government only gave £300,476, or 4 per cent. of the whole. There must, however, be taken into account the elements that compose this sum. £98,704 were paid from the funds of the Minister of Agriculture for losses; and, again, there must be subtracted the sum of £10,100 which was entirely exceptional in its character, as it was voted for the benefit of the victims of the cholera. As directly given, the regular contributions of the Government will therefore be only £191,672. The total amount devoted to the assistance of children in France, in 1885, was £655,772, and the total amount received from endowments was only £14,488. The total amount expended for the support of the insane was £789,332. The Department of the Seine gave 29·7 per cent. of the total amount, while the population was but 7·7 per cent. of that of all France.

THE MINERAL WEALTH OF SOUTH AFRICA.

The coalfield of South Africa covers, says the *Cape Argus* "Annual," a fairly symmetrical area, embracing certain parts of Cape Colony, the Orange Free State, the Transvaal, Natal, and the whole of Basutoland. Starting from a point in the Bamboesbergen, about 20 miles west of Molteno, its boundary line runs in a north-easterly direction, passing near Aliwal North and Herschel, to the Orange River; it then goes to the north, traversing the Orange Free State to a point near the Vaal River; it then turns to the north-east, running parallel to the Vaal River, and passing near Heilbron, Heidelberg, and Middleburg; it then bends to the south-east, finally arriving at the starting point in the Bamboesbergen. The greatest length and breadth of the coalfield contained within this boundary line are 500 and 200 miles respectively, and its area is about 56,000 square miles. Workable seams of coal have been found, and are being worked along the extreme edges of this vast basin, in the Stormbergen near Molteno, at Indwe in Natal, and in the Transvaal; some of the latter is contained in detached outliers of the coalfield proper, but the remainder of the area is practically unexplored, and unknown as regards its mineral resources. Coal is also found in very many parts of Natal. Manganese ore occurs on the ranges of the Cape Peninsula and Drakenstein Mountains. Near Du Toit's Kloof, about thirty miles from Cape Town, a mine has been opened and worked by a private company; the ore is plentiful and rich, yielding from 70 to 90 per cent. Garnets, both red and green, are found in the north-western portion of the colony. They are abundant at the Diamond Mines as coarse fragments, but at the River diggings there are rounded forms of a ruby colour. Agates are found of many colours and shades. In the Vaal River they are so ground down and polished as scarcely to require any further polishing. In the Orange River also they are numerous and handsome. Crocidolite, an asbestiform mineral, occurs in Griqualand West. This is commonly confounded with asbestos, which is, however, quite a distinct species. The crocidolite usually occurs between the bedding plains of jasper, in layers of one to three inches in thickness, and of dark bluish colour. The pseudo-crocidolite is a handsome ornamental stone found in Griqualand West, and also south of the Orange River. It is a species of fibrous quartz that displays a distinct ray of light down the centre when properly cut. The quartz minerals are well represented—they are cairngorms, quartz crystal, amethyst, rose quartz, red and yellow jaspers, and striped and clouded jaspers. Chalcedony is very abundant along the courses of the Orange and Vaal Rivers. Bloodstone is also found in the Orange River. Ores of iron are found widely distributed throughout the Transvaal. Little has yet been done in turning these ores to any practical account, but the natives are skilful in extracting the metal for battle-axes, assegais, and other weapons. Lead is met with throughout the Transvaal, and the ore is generally found to contain more than the ordinary proportion of silver. In the district of Marico the galena is found so very near the surface that, instead of making shafts, the hills where the ore is found are cut down bodily, and many enormous blocks of the ore are unearthed. The proportion of silver to lead in the galena is very rich, varying from 29 ozs. to 93 ozs. per ton; but the average is said to be very high, viz., 63 ozs. per ton, and to increase according to the depth from which the ore is taken. The daily average of lead ore formerly produced at the mines was between 3,000 and 4,000 lbs., although in one day the output reached the maximum of 10,000 lbs. Transport difficulties stood in the way of export, and when arms ceased to be supplied to the natives, the local consumption also ceased, and the mine was closed. In the Middleburg district there is a cobalt mine, but the demand for this mineral is so limited, and the market value so low, that it does not pay expenses of export. Gold in quantities large or small occurs in widely distant portions of South Africa. A great belt of auriferous country, varying both in width and in richness, stretches right across the continent north of the Orange River, from Delagoa Bay to Walfish Bay, while reefs and alluvial deposits are likewise found so far south as Kuysna and in the Cape Peninsula. Serious attempts to turn this mineral wealth to account date back but little more than twenty years, although its existence has formed part of the traditions of the country for centuries past. So far back as 1845, L. von Buch, the German geologist, declared that there was a wonderful resemblance between the geological formation of South Africa and that of Australia, and of the metalliferous strata of the two lands. The value of gold exported through the Cape Colony and Natal amounted in 1888 to £908,694, while for the first ten months of 1889 it amounted to £1,093,084. This amount only represents that portion of gold brought up and exported by banking and mercantile establishments, but does not include a considerable amount exported by private persons, nor the value of what is exported through Delagoa Bay. The value of the diamonds produced in the diamond mines of Griqualand West during the year 1887 amounted to £4,251,670, and in 1888 to £3,608,218.

THE RIBBON INDUSTRY OF ST. ETIENNE.

In a communication which has been recently addressed to the French Government by the Chamber of Commerce of Saint Etienne, it is stated that the ribbon industry has just passed through a very prosperous period, and that it has never enjoyed such prosperity as has been witnessed during the last four years. This prosperity may be attributed to more than one cause. Fashions have always a preponderating influence on the production of St. Etienne, and the low price of silk has in a considerable measure contributed to the activity of the ribbon industry in facilitating the placing of its products. Again, the development of the general well-being and of the national prosperity permits the masses to use articles which were hitherto considered as luxuries reserved to the well-to-do classes. The economic *régime* inaugurated in 1860 had a considerable influence on the development and prosperity of the ribbon manufacture. One of the most remarkable consequences of the commercial treaties was the enabling of the St. Etienne manufacturers to import and utilise the fine cotton threads which were virtually prohibited up to that period, and which the French spinning factories produced badly, if at all. It was in 1860 that cotton entered into the texture of velvet ribbons, and many other articles of the ribbon industry, which permitted a considerable development of its exportation. This development would have been much more important, if by the treaties exaggerated duties had not been maintained on cotton and silk threads. The treaties of 1860 were made on the eve of the secession war in the United States. This country, which used to place at St. Etienne orders amounting to 30,000,000 francs yearly, discontinued its orders all at once. The manufactures of St. Etienne are exported over the entire world. The exportation is effected by French and foreign commission houses established at St. Etienne, and by the manufacturers directly, as well as indirectly by Paris firms. Until late years the exportation was chiefly in the hands of commission houses, but within the last few years the course of business has been modified, owing to the increased facilities of communication. The Chamber of Commerce states that it is difficult to accurately estimate the proportion of goods exported from St. Etienne to that of goods manufactured, because of the indirect exportation effected by the Paris houses. It may, however, be confidently asserted that 75 per cent. of the goods manufactured find their way abroad, while the remainder, or 25 per cent., are destined for home consumption. The exportation from St. Etienne direct represents about 50 per cent., while that from Paris may be estimated at 25 per cent. The value of silk used by the St. Etienne manufacturers during the year 1889 may be estimated at 61,000,000 francs; cotton and india-rubber, 5,000,000 francs; making a total of 66,000,000 francs, or £2,640,000. The cost of the raw material may be estimated as constituting 64 per cent. of the cost of production of St. Etienne ribbons. From this it results that the entire value of the ribbons produced during the year 1889 amounted to about 103,000,000 francs, or £4,120,000. The silk employed in the manufacture of ribbon is almost entirely of foreign production, as statistics show that within the last 29 years only 10 per cent. of native silk has been used, and the average has even fallen to 6 per cent. within the last 10 years. The great perfection to which China and Japan have brought silk cultivation, and the low prices of the silk, account for this increase in the consumption of the foreign product to the detriment of the home product. The Chamber of Commerce therefore thinks that to interfere with the present rates of import duties on foreign silks would be productive of the gravest results. The slightest increase of these duties would, it is said, cause a displacement of the silk markets from Lyons to London and Milan, and would also probably benefit some German town. Concerning the organisation of the ribbon industry of St. Etienne, it is said that it employs 21,000 looms, of which 17,000 are the property of the workmen, on which they work at their own homes. These 17,000 looms represent a capital of from 25,000,000 to 28,000,000 francs (from £1,000,000 to £1,120,000). The number of men and women employed on these 27,000 looms exceeds 63,000. At the side of the weaver there is a complete organisation of artisans, without which the ribbon industry could not exist, such as dyers, silk dressers of various kinds, manufacturers of looms, &c.

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ADDITIONAL LECTURES.

DESIGN APPLIED TO WOOD-CARVING.

By Lewis F. Day.

Lecture I.—Delivered May 1, 1890.

It is quite a common thing to suppose that an art applied can be mastered without any knowledge of art—to forget that the learning of the very least of the crafts is a very serious undertaking, requiring all a man's best energies. Persons who pretend to no proficiency in drawing or painting think that a course of lessons will qualify them to paint on china. Persons who have never drawn or modelled think that they have only to attend classes for a few months and they will acquire the whole art and mystery of wood-carving.

Carvers know better than that. Their own failures have taught them that much. But I am afraid that even among carvers the error still prevails that drawing and modelling are accomplishments beyond what it is necessary for them to acquire. There are plenty of carvers, and some clever ones too, who can neither draw nor model. That may not be such a serious hindrance in the way of carving as I imagine it to be. In fact, if I am right in assuming that carvers are on the whole content with proficiency in their particular craft, that very proficiency (and there is no lack of technical proficiency in carving now-a-days) goes to show that inability to draw or model does not preclude success in carving. But it does absolutely stand in the way of design.

Design presupposes of course very patient study; but actual designing is a matter of impulse—it is done at white heat. Now long before a man has had time to carve a thing, the first impulse is gone—the fire is out, so to speak,—which may account for the tendency of the carver (a fault, as I think, characteristic of the craft as a body) to lapse into mere execution.

It is not surprising, when you think of it, that Grinling Gibbons should represent the technical ideal. No one who is himself a workman and knows what workmanship is will begrudge an artist like Gibbons the admiration due to his most masterly technique—in respect of execution he may perhaps approach the ideal perfection—but he does not approach by a long way the designer's ideal (not so much through any fault of his, probably, as owing to the period in which it was his fate to work).

But, to return to the point, if you want to design you must first of all learn to model, or better still to draw. Only by that means can you acquaint yourself sufficiently with all the good things that have been done. Only by that means can you, when you begin to design yourself, knock out a notion with the ease and rapidity which allow of your expressing it, somehow, whilst it is vividly in your mind.

Were time, even, of no account, carving would not do—in designing you want more or less to feel up to your intention, and carving is a precise art; you want to build up your scheme, and carving only allows you to cut and trim: the very fear of going too far and cutting away too much, is enough in itself to damp the ardour of design.

Don't think I am making too much of this. If you are to spend weeks, and perhaps months, in the execution of your carving, it is not too much to ask that you should spend a proportionate number of hours or days on its design—and in designing you are bound in reason to work in a medium which allows every opportunity of alteration, modification, development, as the idea shapes itself into a design. This is possible in charcoal, pencil, colour, clay, wax,—but not in wood.

I do not mean to say that you should make a perfect and finished drawing of what you are going to carve—that would be doing your work twice over. I don't even say that you should be able necessarily to make a finished drawing at all (although in the exercise of your calling you will find it often very convenient to be able to do so—for a genuine sketch or working drawing is in too many cases absolutely incomprehensible to the person for whom the work is destined)—but I do mean to say that every carver should be able to make a drawing which conveys to him (no matter what it looks like to anyone else), clearly and definitely, the design he is going to carve.

Everyone, I suppose, does make some sort of scribble on the wood before he takes up his tools. That is not what I mean. I mean a drawing quite true in its lines and absolutely thought out as far as it goes.

And it should go at least as far as to give not only the lines and masses of the composition but the outlines of the detail. It should be quite clear to him also, whether he shaded his drawing at all or not (I think myself that some shading could not but help him better to realise the effect of his work) it should be quite clear to him which portions of the work were on which plane, and so on.

The actual modelling of details is, no doubt, as well, or better, left to the impulse of the moment when it comes to carving them. You get by that means the charm of spontaneity and freshness. But you don't want to have to think when you are carving. There should be no hesitation then. You want to see the line there that you may quite freely follow its sweep. The only kind of thinking which would not hinder you is that unconscious kind of thought which is better described as feeling.

I think it is because the carver is not more expert with the pencil that our admiration of very beautiful carving (and there is beautiful work done now-a-days, whoever may lament the degeneracy of these later times) is often discounted by a certain resentment at the poverty of its design. The carver has thought too exclusively of his carving. An artist must think also, and think first, of his design. A mere carver (I don't say mere carving is easy) a mere carver is an artist minus one at least of his most indispensable faculties—design.

It is my purpose, then, to talk to you about design—in reference indeed especially to wood-carving, but still my subject is design, not wood-carving, about which I have no claim to speak with anything like authority.

Neither have I any intention of covering the whole field of design, which would lead us, even in reference to wood-carving, into the realms of sculpture.

I mean to take practically no account of figure work (which again is not my province) nor indeed of work in the round generally. I shall have quite enough to do in the course of three short hours to expound some principles of design as they affect carving in its application to joinery and cabinet work—to work, that is to say, comparatively restrained in character and moderate in relief. The competent "sculptor in wood" as he may be called, must be presumed to need no advice of mine.

The time honoured way of treating a subject like wood-carving (or its design) is to go back as nearly as possible to the flood, and describe the stages through which the art has successively passed.

That would be more interesting if the thing had not been done so often, and if the historic development of his craft were of more immediate and practical importance to the craftsman.

As a matter of fact, a great part of such discourse is history pure and simple, and has an interest almost entirely historical. It has occurred to me to suspect that workmen attend lectures with the idea of getting out of them something really helpful in their work, something to the immediate purpose, and that a strong dose of history might send them to sleep.

Well, now, the purpose of these lectures is not to give "tips" to the carver. No one in his senses supposes that any, even the lengthiest series of lectures will supply the place of independent study and workshop practice. But, at the same time, it is the business of the lecturer, as I understand it, to be careful not to bore his audience, and certainly not to send them away asking themselves whatever was the use of attending?

So, I am not going to begin with ancient Egypt, to bring you by way of Greece and classic Rome, through mediæval Germany, and renaissance Italy, and pre-revolutionary France, to the great Exhibition of 1889.

If I can't promise never to be dull, I can undertake to bear in mind throughout that you are practical workmen and want to get something practical out of me. I must do you the compliment however—and I hope it is not a bare compliment—to consider you as something more than learners, journeymen, or master-carvers, interested only in the trade side of the question. I have no intention of shutting my eyes to that side of the road we have to travel, and passing pharisaically by—quite the contrary—but what we have to consider here is not so much how you are to learn your trade, as how to infuse into it the most essential element of art.

I have undertaken to touch as sparingly as possible upon ancient history—it is not history, as I said, but carving which concerns us—and if I go back for a moment to the remote past, it is only for a moment, and only in order to begin at the beginning of workmanship. This going back is indeed necessary to the proper understanding of the finished art, which is only a development of practices often best explained in reference to the more archaic and less sophisticated work.

Carving, as it happens, begins with the beginning of ornament itself.

It grows out of a certain discontent we have with plain smooth surfaces—out of the natural irritability of man, I may say, and of the artist in particular; for he belongs to the proverbially irritable race of poets—or at least he should. He cannot keep his hands, I will not say precisely from picking and stealing, but from fidgetting something. Give a boy a knife and he will begin instinctively to notch a stick with it; give him a sharp-pointed instrument and he will scratch the first smooth surface that comes under his hand.

That is precisely what mankind in its boyhood did. The cave-man scratched the bones strewn about his cave. The South Sea Islander notched his paddle and the prow of his canoe. Notching and scratching then are among the earliest, if not the very earliest forms of ornament. And they are the starting-points of carving as we understand it, notching and scratching, that is to say chipping and engraving.

Curiously enough, these two forms of aboriginal fidgetting indicate the two directions in which the artistic ingenuity of man has since developed itself. The cave-man scratched the likeness of a reindeer; the savage notched away systematically, evolving as he went on forms more or less out of his own head—*i.e.*, not ostensibly borrowed from natural objects about him. We have here the beginnings of pictorial art and ornament.

Our English "chip-carving" scarcely comes under the category of serious art. There is perhaps something essentially barbaric in such work. But our easy scorn is not altogether to our credit, so long as a New Zealander can give us long odds and beat us into fits at it. For my own part I would rather see the beginner trying his prentice hand on some such simple work than bursting himself with ambitious efforts which only show how far he is from realising all he has to learn. The story of that frog is not without its moral.

The perfection to which chip-carving, or something very like it, may be carried is best seen in Oriental work—and indeed in some of the most elaborate developments of Mohammedan carving one still traces the relationship. The design might have been evolved out of the use of the knife—and one never quite loses sight of the chip. It is very plain, to my thinking, in a cupboard door from Cairo (in the South Kensington Museum) which I show you on the screen.

That commends itself to me as a most satisfactory floral panel—it covers the space perfectly, the lines are good, and it grows, though the floral types, it must be owned, are rather mixed; but there is nevertheless a certain oneness in the forms because they are all more or less according to the knife, if not actually inspired by it: anything simpler and more direct it would be difficult to conceive—just two cuts and the leaf or petal is rendered: some of the flowers in front view are practically chip-carving, and nothing more.

Our Western carving grows more out of engraving—at first perhaps with the knife and then with the parting tool and gouge. In its roughest form this is seen very distinctly in old oak chests and settles—in certain German Gothic work and in some very effective Scandinavian work. The wood is often rather cut and slashed than carved; but even in connection with such incising, there is a certain amount of geometric chipping, as if that too came by instinct — as in fact it did, growing, as I said, out of the use of the tool.

The second, and so far as we are concerned the more important form of carving, is, then, in its earliest form a kind of engraving. Upon the plain surface of the wood, the artist simply cut his design in firm outline, what we should do with a parting tool, but it was done as I said in the first instance with a knife—not a bad instrument either: one of our most accomplished wood-engravers told me that he had no more serviceable tool than a keen-edged knife. Besides, I do not know when the parting tool was first invented, but I am quite certain it was long after men had learnt to incise in wood.

The furthest development of this flat work occurred in Italy where, in the 14th century, it took the form of most elaborate figure work, not merely of angels and other single figures, but of groups of fine ladies, dressed in their very best, crowded hunting scenes, with birds and beasts and forest background, all more or less framed in ornament. Some indication of shading was also given, mainly in bold sweeping lines, more or less parallel, such as we see in the best monumental brasses, not cross-hatched, and leaving the greater part of the surface of the wood intact, so as to give value to its quality. (This quality of the material is a consideration which some of our accomplished carvers are too apt to lose sight of.)

Engraved work soon begins to be carried at least one step further—the background is slightly sunk, "grounded out" as we say. The fact that this ground was sometimes filled in with coloured mastics or cements, proclaims such work to be incising rather than carving: it hardly pretends to it; but it is art, there is no doubt of that—and, what is more, art within the scope of those who can draw a firm line. As such it is at all events worth the consideration of the beginner, and especially of the amateur.

Wood-carving in its fullest development is an art (I will not say a fine art) but an art not everyone has the opportunity of pursuing and fewer still have the faculty of carrying to perfection; but the simpler and more rudimentary forms of wood-carving are capable of development, and well worth development; and it is a great pity that there are so few persons modest enough to take to them seriously and show what can be done in them.

They demand little more than patience, ingenuity, and taste. I would not be understood to imply that taste is the common commodity it is assumed to be: it is, on the contrary, exceedingly rare. But there are many persons of the requisite taste who can never hope to become accomplished carvers in the full sense of the term, and who might well do excellent work of a modest kind, but for the curse of a misplaced ambition.

So far, design has been considered mainly as a question of line: that is all very well in its way; but it is the way more proper to engraving than to carving. It is not well in carving to begin with so exclusive a consideration of line. Except in the case of very low relief (which we shall have to consider later on) the more important consideration for the carver is mass. And in work of any pretention to design mass has always been if not the starting point at least a matter of prime consideration.

In the Swedish work, in German Gothic, in our own Elizabethan strapwork, the same simple plan of design is followed—that, namely, of conceiving it more or less on two planes, that is as pattern, raised, and ground, sunk, throwing it into relief.

This however is not enough to satisfy for ever the artistic soul. It brings us only to two plain surfaces instead of one. As soon as ever a man has achieved proficiency in any one direction he craves, forthwith, to supplement his work by some additional interest.

The designer proceeds accordingly to incise certain subsidiary lines round the edges of his forms, and to make certain depressions of more importance in the ornament, scooping out details here and there with the gouge. In the same way the absolutely flat strapwork of the Elizabethan period was mainly the work of the less experienced manipulators. Given the design, not always irreproachable, any one with the command of his tools could execute that kind of surface work with his left hand.

But so soon as ever he began to feel his power he must needs model the surface of the ornament itself—ever so slightly at first, seeming to strive for the utmost delicacy of relief, using only the flattest of gouges, showing what subtle variety of surface he could get within what was practically little more than surface carving; later on exaggerating the projecting ends of his straps beyond the bounds of taste or reason.

In the rather elaborate bit of Norwegian work kindly lent to me by Miss Rowe, you see how the surface of the design is as it were deeply engraved—it is not modelled so as to give gradations of relief, higher and lower, but the surface of the scroll is carved over with pattern very much in the manner of Byzantine carving, to which I suppose it is related. It is worth noting what an exceedingly rich effect is produced by these very simple means.

In the lowermost example of the three next on the screen—German I imagine (this slide has been kindly lent to me by Mr. Bliss Saunders)—there is also as it happens a certain Byzantine character in the design—and you will notice that here again the surface detail does not tell you much more than the outline did. Still less does it give relief: it is meant only to enrich it—and that it very effectually does.

In the two contrasted examples next shown on the screen there is a valuable lesson in design. The one is an Icelandic box of comparatively recent date, but obviously designed on traditional lines: the other is an Italian frame of the 16th century. In the box-panels you have a very simple scroll fully occupying the surface. It is perfectly flat on a ground very slightly sunk, an engraved line round the edge of the scroll (such as I spoke of just now) emphasising it, and the terminal foliations (if anything so conventional can be called foliation) more emphatically gouged out—so that the groups of three leaves or lobes in the centre of the spirals, appear to be relieved against the scroll itself, which thus forms a sort of intermediate background to them.

That marks already an advancing step in design.

The Italian frame, as you see, is on very different lines, and the detail also is quite different. Design and execution both reach a much higher degree of refinement.

But you have in both cases flattish strapwork enclosing little bits of conventional foliation relieved against it—the difference being that in the Italian work the strapwork is ever so delicately modelled and its edges very knowingly bevelled, whilst the foliated work, instead of being a mere sinking, is carved in relief, only on a lower plane than the straps, and the actual background is practically not seen.

This frame is to my thinking an exceptionally good example of the judicious contrast between plain surface and delicate relief. But what I want especially to point out is that, far as it is in advance of the ruder Icelandic work, the same principle of design underlies them both. They are two developments of the same idea, the idea, namely, of enriching the wood without too much interfering with its even surface—of making, as much as possible, the surface of the thing the surface of the decoration—of cutting away as little as possible of the ground, and of making the simpler ornament itself a background to the more elaborate.

That is one way of designing wood carving.

I referred a moment ago to the contrast between plain and modelled surfaces in carving—that is the first thing the designer has to consider. And I may as well say here, in reference to comparatively simple work (what applies to all work whatsoever), how essential it is:—

(1) That the lines and distribution of the design should be from the outset very carefully considered, and

(2) That ornament, of whatever kind, should be used with reticence.

This same reticence is naturally lacking in the art of the savage, who for days together had nothing better to do than whittle the handle of his club—and so he went on whittling until he had occasion to knock someone on the head with it.

In Indian wood-carving again, also more or less barbaric in its richness, a similar exuberance results from very much the same causes. The Moslem's time is not yet money, and he worries his work with an industry very nearly approaching to idleness. Even amongst ourselves, by the way, there are men whose work ought always to be taken out of their hands before they have had time to ruin it with over-elaboration.

It is worth noting, however, that both Indian and South Sea Islander do, by leaving no absolutely plain surfaces and covering every inch of the work with detail, manage to get a certain homogenousness, which is not unrestful to the eye. Their work arrives, in a way of its own, at a degree of repose one would not have expected, a repose which modern European art has not shown itself capable of arriving at by like means.

The fact is that in Bombay work the detail, which is in the nature of surface carving, is lost to the eye, and the mouldings or other more or less constructional lines, which are more strongly marked than anything in the carving, assert themselves. This is pretty plainly shown in the example on the screen—the upper half of a door and doorway of Indian, I think Bombay, workmanship. For all its extreme elaboration (every portion of the work is carved) the architectural and structural lines are perfectly preserved—at a certain distance you would see them and not the ornamental detail. And yet mouldings, panels, stiles, all is carved—only with judgment (if not with reticence) surface work contrasting with stronger relief, and so affording the necessary contrast. That is not our way of doing it, but it is very well done.

There is a similar richness in the Renaissance work next shown—the upper portion of a cabinet in the South Kensington Museum—which owes I cannot help thinking something to Indian influence. This is French work I believe, but France borders on Spain, and we know the intimate relation between Spain and the Indies in the 16th century.

Here the carving of the constructional lines is as bold as the rest, but the simpler and more rigid bead pattern contrasts quite sufficiently with the more important scroll work of the panels and so on. Practically what I said of the Indian doorway applies equally here.

I have yet another example of rich all-over work to show you—a cabinet (distinctly French this) of the Henri II. period. In this case the extreme delicacy of the carving and its very slight relief allow the merest lines to emphasise the divisions of the composition—and, in contrast with the projection of the larger mouldings, the carving on them is so flat as to be comparatively speaking mere engraving —but as a matter of fact the work is very delicately and subtly modelled notwithstanding the slightness of the relief. I look upon this as a very refined and beautiful piece of work — suggestive of a delicate treatment seldom seen in old or modern cabinet-work.

In the lowermost of the four cassone fronts (next shown) you will see I hope (though the slide is not very clear) that the ribbed mouldings are intended to contrast with the richer carving. You will see also where that moulding has come away and left a plain space, how much more valuable that is than the moulded lines—conveying a double lesson, (1) the moral of simplicity, (2) the inadvisability of planting mouldings on, without regard to construction.

In savage surface decoration where there are no mouldings, there are usually bands of ornament pronounced enough to fulfil a similar function.

The method more natural to us (by reason both of our temperament and our economic system) is to contrast plain surfaces with rich, and so make the most of the surface of the wood.

The problem we have to solve is how with the least waste of energy to get the happiest effect—and the due balance of rich and plain, of rough and smooth, becomes thus a prime condition of design. So far, I don't think we have any cause to quarrel with the commercial considerations by which the carver's art, in common with that of other handicraftsmen, is bound—any more than we have occasion to quarrel with our food because it is not all fat. A certain amount of lean is palatable as well as wholesome. As to the relative proportions of fat and lean, tastes may be permitted to differ; the natural stomach yearns perhaps for a preponderance of lean. Anyway we shall not be far wrong in saying that the proportion of carving to plain surface should be in something like the ratio of fat to lean. That allows for considerable variety of choice as to the due proportion of enrichment—according to its character and to the idiosyncrasy of the individual. Even those who like their morning rasher fat prefer their beef and mutton rather leaner.

Whatever the proportion of carving, then, to plain wood, and however it be distributed, whether in masses more or less isolated, or spread comparatively evenly over the ground, some proportion of rich and plain has to be observed. That is the starting point of the designer.

The proportion of carving may be settled for you—as, for example in wood-panelling, where you are not asked to carve the stiles but only the panels, or, it may be, only the mouldings. In either case, the amount of carving being settled for you, and its whereabouts, that will determine to some extent the character of the carving.

If the matter rests entirely in the carver's hands, then (unless he means to carve the thing all over, Indian fashion, in which case he must be very careful to make the character of his detail such as not to interfere, whether by its scale, its lines, or its relief, with the lines of the moulding, and so on) he must settle first of all where his enrichment shall come. He may elect, for example, to cover the panels only, or the mouldings only, or both, or he may prefer to enrich only the pilasters, caps, and frieze, keeping his panelling altogether plain to show to full advantage the grain of the wood. In any case, design being essentially a logical art, it is necessary to work on some system.

It is rather interesting to notice the entirely different system on which the simplest architectural wood-carving may be planned. In the old timbered houses at Brunswick it is always the constructive timber-work which is carved—beams, posts, trusses, &c., were all most elaborately and even floridly carved; but yet the constructional lines ruled everything. At Hildesheim, on the other hand (only an hour's journey distant), it was the panels that were the main feature—if the constructive beams, &c., were carved it was only as a framework to the panels.

I don't say that either system is better than the other; much must always depend upon circumstances; everywhere you want supports to look substantial, and framing to look rigid, mouldings to mark the divisions, and so on; but some system you must adopt, if you would have the thing look one when it is done. You must know what you want to do before you can well do it. And though your system need not be apparent to the casual observer, there is no harm in revealing it. One rather likes to see clearly the task the artist set himself. It is by no means a compliment to him to ask yourself what on earth the man was aiming at. So far as handicraft is concerned rather too much has been made of the art which consists in hiding art. It is all very well to quote Latin—but it does not necessarily clinch the argument.

Failing constructive features, architectural or what not, which give you the outlines of your scheme, you will find it necessary to divide up all but the smallest areas into compartments or divisions of plain and carved, not only to economise carving, but to give value to the carving.

Take a picture out of its frame and it requires an expert to see that it is worth anything. And so with carving. The more precious it is the more worthy it is of framing and of an ample margin. The art of design consists, to a great extent, in leading the attention, gradually but surely, up to the point or points of central interest. And the surest way of emphasising a point is to isolate it, just as you pause before a word to which you wish to draw attention.

And though we know this theoretically, we continually forget it in practice;—even the best of us are apt to overdo everything. It is difficult to realise how much more the half may sometimes be than the whole. By worrying the wood all over, we (who are not Orientals) lose its surface and its character; we destroy all possible breadth; and we materially lessen the value of the good work we may have already put into it.

It was my misfortune once to have to sit out a very tedious burlesque in which the comic villain had one comic catchword, which he succeeded in dinning once and for ever into my memory. Whether it was paraffin which he mistook for whisky, or poison which he had imbibed under a similar mistake, he was careful always to inform us that he had had "not too much paraffin but just paraffin enough," "not too much poison but just poison enough"—and so on *ad nauseam*. I shall have taught you something to-night if I can only impress upon you the necessity of introducing into your carving not too much ornament but just ornament enough.

That may not help you to determine precisely where you should stop; but it is something if you can only bear in mind that you have to stop. And if you hesitate as to the point at which to stop, it is more than probable that you have already reached it.

You are always more likely to err by excess than in the exercise of restraint. Unless you distinctly feel that further enrichment is wanted, you may be sure that you have indulged already if not in too much ornament, in quite ornament enough.

So far the distribution of design has been considered mainly in connection with patterns merely grounded out and only so far carved as not greatly to disturb the surface of the wood. But however much you carve the design, however elaborate and intricate it may be in detail and in surface, whatever degree of mystery you might impart to it, though you lose it at times where it dies into the ground, you begin, all the same, by planning it.

The first thing you have to do is to set out its lines, distribute its masses. According as the relief is to be low or high you begin with the consideration of line or mass. The important thing in low relief is line. In high relief mass is all-important.

In the one case then you start with certain skeleton lines which you proceed duly to clothe in foliage arabesque or what not. If you dissect a Greek scroll you will see that it is little more than a succession of spirals growing the one out of the other with an added husk or sheath at the point of junction (they added little tendrils and flowers to fill up, but the scroll was as simple as I have stated).

The Romans made much more of the sheath, wrapped the scroll up in it entirely; but their clothing of the line is only a development of the simpler Greek scroll; and the same with Renaissance foliage, which is not so much a conventionalising of the acanthus (by which name it goes) as an attempt to clothe more or less on the principles of nature lines not natural at all but purely arbitrary. It follows logically that the foliage also must be arbitrary; and we find in all periods of historic art this due relation of foliage or foliation to the lines to which it is accomodated.

In the other case you first map out the masses of your design and then break them up into detail. That is to say—you begin as it were by designing your background—considering the pattern more as a silhouette against it. Within the outlines of that silhouette you have then to scheme your ornament, making it so to speak grow to fit them. You will of course have from the very beginning some idea as to the way you will occupy them, and your masses will be determined with a view to such convenient occupation, but for all that the process is as I say.

And the two ways of looking at a design are—

(1) To regard it as line more or less assisted by mass,

(2) As silhouette or mass, helped out by lines.

The one way is appropriate to low relief, the other to high relief.

There is a middle course (which in practice is the best) and that is to determine both lines and masses before definitely fixing upon either.

There are two very handsome doors, Italian work, now at the South Kensington Museum. The genesis of the design in the case of the narrower of the two is particularly clear. The artist began first with a border (which he carved eventually with a pattern almost Assyrian in its character). Within this he devised another broad border, carved with a sort of reel pattern; but to mitigate the obviousness of this device, and also to prevent the appearance of narrownesss in the panel, he made the inner moulding break across it at top and bottom, fret fashion. The panel itself he divided up into three ovals, and, lest they should appear too uniform, he bordered the centre one with heavy mouldings, making a pronounced feature of it, and carved the other two comparatively lightly.

In the companion door the scheme is not so neat. The designer first shortened his panel by narrow cross panels (with fret-like ends again) and having now reduced his centre space to a rather squat shape, improved its proportion by introducing an oval not occupying the full width of the space.

Both of these doors are fine examples of treatment, large in style without any very elaborate detail.

The best plans are invariably the simplest. Without simplicity of composition dignity of design is almost out of the question. Moreover, if the lines and masses of your composition are in themselves graceful and well-proportioned, if they are right, you are under no temptation to lose them in elaboration, and may well be content that the carving should contrast frankly, however delicately, with the ground. This is not a law of the Medes and Persians precisely, but it is an excellent working rule.

You shall see two or three examples in which it is observed.

Here are two panels from the choir stalls of S. Pietro at Perugia. These panels are in fairly low relief and the design is therefore conceived very much from the point of view of line—and the lines are exceedingly graceful. But they are shown now as instances of design clear cut against the ground: the lines are not fogged in any way, but frankly challenge your criticism.

So again in the little panelled room at the chateau of Blois. I show you a photograph of some of the panels and a portion of the room showing how they occur. These little panels are all different in design, and the ornament tells clearly against the ground. Unfortunately the carving is more or less blurred by gilding.

In the next examples—a panel from South Kensington Museum and a desk-end from the Laurentian Library at Florence—the carving itself is carried further: there is more variety, more relief, and more modelling; but the outline is never quite lost; it tells as design and not merely as so much richness.

In none of these examples is there, as I said, any attempt to disguise the lines of the design—they stand in deliberate relief against the ground.

In ornament of any degree of elaboration you will further see a contrast between simple and elaborate carving, large and small detail, broad and finished treatment. A striking instance of such contrast occurs in the ceiling of the Salle de Diane in the Palace of Fontainebleau, which contrast is emphasised by the very judicious use of a little colour. You will see how the broad wave pattern contrasts with the richer carving, and how, in that, the little cartouches with the double D's contrast with the smaller detail, which is by comparison a sort of filagree, whilst the interlacing crescents of Diana form a sort of intermediate link between the lighter and the heavier detail. For breadth and dignified simplicity of effect that is a remarkably fine ceiling. A richer example occurs in the little ceiling from the Palace of the Gonzagas, now called the Corte Reale, at Mantua — really little more than the soffit of a deeply recessed window in the *camerino* of Isabella d'Este. The contrast of those broad bands, delicately carved and modelled, and of those rich circular bosses, with the graceful arabesque and emblems within the diamond spaces, is just right. And those three little tablets across the centre, notes of severe simplicity, remove the danger there might have been of a certain mechanical construction in the design.

Another little ceiling, and part of a cove beneath it, also from the Corte Reale at Mantua, fulfil the same conditions of design: in fact the border between the two reminds one forcibly of the Fontainebleau ceiling already shown. In the cove that plain panel, just inscribed with a bar of music, is very valuable amongst so much rich detail.

It is in view of this necessary contrast that designers of the 16th and 17th centuries resorted so largely to the device of that strapwork which, as I said, is more or less akin to the simplest form of carving. In work of the Henri II. period a very marked use is made of the device. It was not of course peculiar to wood-carving; you see it in silversmiths' work and very especially in the tooled bindings of books; but it lends itself very admirably to our purpose. It is most effective when it is most delicately carved, just sufficiently depressed here and raised there, so as to give variety to the surface and catch the light at all manner of different angles, but yet by comparison flat enough to act as a foil to the richer carving. There is a beautiful example of such strapwork in the arcaded support of a Henri II. table at South Kensington Museum, very delicately carved and perfectly designed so far as line and composition are concerned —admirably adapted, too, to the subordinate place it occupies, between the more richly carved supports at each end.

Such flattish and even quite flat bands are nowhere more effective than on the broad mouldings of the period, which are usually very elaborately though very delicately carved, so delicately as to be sometimes comparable almost to engraving. The reason for such slight carving is obvious—the contour of the moulding is thus preserved; the flattish interlacing strap-work still further emphasises the shape of the moulding, at the same time that it affords the element of contrast within the ornament itself. It fulfils often a further function of giving cross lines to break the too horizontal tendency of the constructional lines of furniture.

Let me explain, that I am not proposing that you should adopt the style of Henry II. or Elizabeth, or the equivalent Italian manner, but simply pointing out the advantage of reserving certain flat or nearly flat sections as counterbalance to more elaborate carving.

Not only is it necessary in design to observe from the first a certain relation of bold and delicate and intermediate parts, and a certain gradation from one to the other—but it is further important to preserve that same proportion, and relation, in the finished work.

In all good work you can see, in fact you never lose sight of, the lines it was meant to take. It is perfectly clear that it was disposed just so and so; massed together here, opened out there, and so on, with the distinct view to composition, balance, grace of line, or breadth of effect.

There is an obvious instance of that in the panels of a cabinet recently acquired by the South Kensington Museum. (It is said to be Spanish, but I am more inclined to think it may be French.) Now in the two upper panels there is no mistaking the purpose of the designer. You can see exactly how he went to work. Those little nondescript figures on each side of the medallion are quite plainly suggested by the necessity of supporting the weight of the medallion itself—I don't mean holding it up (which as a matter of fact they are actually doing) but of keeping it in countenance, and balancing it. The little vases of fruit and the grotesque heads with which the scrolls terminate are quite as obviously designed to keep these secondary masses company; and the lines connecting them are clearly devised for that very purpose of connection.

I look upon these two panels, with their perfect balance of weight and simple grace of line, as just about perfect specimens, I will not say of wood-carving exactly (because they are rather more suggestive of modelling than of carving) but of one way of occupying a panel.

In the bench ends shown, from S. Severino (Naples) you may see how in the very richest carving, so rich as to be almost florid, it is possible to maintain, through all elaboration, the broad lines on which it was composed.

You can see, especially in the smaller of the two (mainly, I think because it is the better photograph) how distinctly symmetrical the *motif* was, and how the features of especial interest, such as the demi-figures grouped in the lower part of the panel, grew in their very inception out of the consideration of composition as they grow in effect out of the scroll.

The balance of design is here as true as the carving is skilful. The value of that plain central jewel is enormous. I don't mean to say that the idea of wooden jewellery is a very bright one—but the value of that mass of comparatively smooth surface just there is incalculable—and if that was the only way of getting it (I don't say it was, but probably the artist saw no other) then I for my part forgive the jewellery.

A value of similar kind attaches to occasional straight lines, or other such notes of severity, in the midst of arabesque. Suave lines alone induce a sense of sickliness. And even though the line or object may not be in itself beautiful it is more than excusable for its contrast to the sweet lines about it. The music of perfect form is not made of only mellow notes.

There is an instance of this in the panel from one of the stalls of St. Denis. That tablet in the centre is not in itself an interesting feature; but, take it away, and you will feel the want of it badly. So with the rectangular panels within panels at S. Severino (Naples) in the lower of the two illustrations on the screen.

(You have here by the way two views of I think the richest of carved choirs I have ever seen. It is almost Eastern in its gorgeousness. I showed you just now two of the bench ends and shall I have other details to show you later on.)

To refer to these particular panels, theoretically I am not much in favour of tablets without inscriptions or of miniature panels within panels; if you can get over the conditions of compositions without such devices, so much the better; but composition you must get—and to that end any honest expedient is permissible. Who shall say what is precisely legitimate? Composition counts for more than purism in design. I won't say don't hamper yourselves with theories or tie your hands with prejudices. I know that I have theories yet to be put into practice and prejudices never to be eradicated—and I hope you have; but don't adopt them lightly or without knowing what they imply, and above all don't take them on anybody's word; let them be the result of personal conviction, and you will find them helps then, not hindrances.

What you feel to be right you must do, though all the world said it was wrong.

But because this man has pronounced against naturalism or that man against convention, because someone swears by this style or another by that, don't shut your eyes and swallow his dogma, cutting yourself off thereby from the possibilities of art that lie in these forbidden practices.

No one has authority to forbid. If preachers and prophets cannot succeed in convincing you, without the shadow of a doubt, that this or that is contrary to right and reason—then, reserve your freedom of choice. Least of all, don't take anything I say for gospel, but only for my honest conviction. In the end it is your own conviction that you have to follow not mine nor any other man's.

But so long as you are students you must have faith—without it, at all events, you will not move mountains. Better put your faith in someone not quite worthy than be cocksure of your own self-sufficiency: in that case you are sure to misplace your confidence; but all fresh enthusiasm is good, and without it you will never do anything to arouse the enthusiam of others.

Miscellaneous.

THE INDUSTRIAL ARTS OF INDIA.*

The so-called "Code of Manu," in its present text, is generally believed to have been composed at any time between the 2nd century B.C. and the 2nd century A.D. It is obviously founded on older texts, and through them refers back certainly to 500, and possibly to 1000 B C. But it suffices for my purpose that the Code should be accepted as an authentic record of the indigenous arts of India for about the period of the Christian era; and, of course, for the period with which it really is contemporary, it is of priceless value to the student of the arts of India; for every page of the Code shows that the social and industrial organisation of the country, and therefore also the local characteristics of its arts, have remained unchanged for two, and we may presume for even three, thousand years. It is indeed the authority of the "Code of Manu" that has preserved them from change, and secured their hitherto uninterrupted, and we may hope their still indefinite, continuity.

The India of the "Code of Manu" is a country of magnificent picturesqueness and the highest fertility. Its elevated forests of arboreous figs, silk-cotton trees, *khadiras*, *pulasas*, palms and bamboos, are the home of the tiger, lion, monkey, and peacock; in the more open sub-montane tracts appear the elephant, the black antelope, the red deer, the spotted deer, the gazelle, the wild boar, the porcupine, the hare, partridge, and peacock. In the alluvial plains are wide fields of grain of all sorts, sugar-cane, and rice, and round the numerous villages, rich gardens of shrubs, creepers, flowers, and every kind of esculent vegetable, including garlic, leeks, onions, and mushrooms. Here also are to be seen bullocks, cows, and buffaloes, sheep and goats, horses and donkeys, the domestic cat, and the village watch-dog, the village scavenger pig, and the village cock to crow the morn. However, I am concerned to-day not with the landscape of the "Code of Manu," but with its arts; and I find it mentions temples [viii., 248, ix., 289, 285], ruined temples [iv., 46], and idols [iv., 39, 130, viii., 87, ix., 285]; tanks, wells, cisterns, and fountains [viii., 248, ix., 279]; bridges [ix., 285]; fortresses and hill forts [vii., 70-76, i., 252]; palaces, with flags streaming from high poles [vii., 70-76, ix., 285], royal storehouses and armouries [ix , 280]; bows and arrows [iv., 160], and all manner of lethal weapons [vii., 90]; chariots [ix., 280], carriages [iv., 202, 232, viii , 291], and carts [viii., 209]; "white apparel" [viii., 231], "dyed cloth of hemp, linen, and woollen" [x., 87, xii., 66], "silk stuffs" [v., 120, xi., 169], and dresses of every description of fabric [iv., 66, 188, 231, ix., 76, 219]; indigo [vii., 90], and lac [x., 82]; shoes [iv., 66], and parasols [ii., 246, vii., 96]; coral, pearls, and other gems [xi., 168, vii., 218, viii., 100, 323]; gold ear-rings [iv., 36], and other personal ornaments [ii., 194, iii., 59, iv., 66, ix., 219]; perfumes [iii., 209, iv., 250, xii., 65]; seats [iv , 202]; couches [iv., 250]; and Nepaul coverlets of wool [iii., 234]; lamps [iv., 229], articles of stone [vii., 132], ivory and horn [vii., 121]; and of silver, plain and enchased [iv., 230, v., 112, xi., 118]; spoons [v., 117]; water vessels [ii., 64, vii., 132, viii., 319], dice [iv , 74, vii., 50]; beds [iv., 202, 232], and blankets [v., 120].

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* Speech by Sir George Birdwood in the discussion on a paper on "Indian Industrial Arts Revival," read before the East India Association. Those seriously interested in the subject of Indian art should read the following remarks in connection with Sir George Birdwood's remarks on Mr. C. Purdon Clarke's paper before the Indian Section of the Society, April 15th last. (See *Journal*, vol. xxxviii., p. 511, April 18, 1890.)

The artisans mentioned are architects, carpenters, basket makers, armourers, goldsmiths, tailors, weavers, and oil-press men; and although they are all classed among the lowest castes, the handicraftsmen's calling is held in so high honour by the "Code of Manu," that, in the chapter on purification, it is declared that, "the hand of the artisan [in his work] is always pure" [v., 129]; and, again, in the chapter on the relation of the sexes, that, "mendicant bards, men who have performed the initiatory Vedic sacrifice, and artisans are not prohibited from speaking to married women" [viii., 300]. It must be remembered that the "Code of Manu" refers to all these handicrafts and handicraftsmen only indirectly, and merely in their relation to the theocratic scheme of life of the Hindus. The spiritual abstraction of the compilers of the Code from the temporal world is well illustrated by the opening lines of the verses setting forth the gradation of the coinage of ancient India, viz.:—"Those technical names of fixed quantities of copper, silver, and gold, which are generally used on earth for purposes of business, I will now fully declare." In the same spirit, reference is made to debts, contracts, tariffs, and customs dues, and to sea voyages and foreign trade, both of which are strictly forbidden. The fact is the foreign trade of the period had overthrown the authority of the Brahmans, and commercialised, that is, internationalised Hinduism into Buddhism. In the West, the same great commerce internationalised Judaism into Christianity, and later, in Arabia, into Mahomedism; and the strong anti-commercial animus of the "Code of Manu" marks the reaction of Brahmanism against Buddhism. Now, when all this is considered, the immense importance of the Code as a record of the arts of India about the Christian era will be at once recognised: and it affords as authentic and incontestable evidence of the condition and character of the contemporary arts of India as do the carvings on the gateways of the *tope* at Sanchi, and the mural paintings of the caverned halls at Ajanta.

Let us pass next to the Ramayana and the Mahabharata. If we assent to the very latest of the dates accorded to these great national epics of the Hindus, they still belong to a period long anterior to the establishment of the Mahomedan dominion over Northern India; and while of course they are of no authority on the state of the arts of India, at the traditional dates of the mythical events—the great war in Bharata, and the conquests of Rama—they commemorate, they provide absolute evidence of the general industrial condition of India at the time when they were reduced to their present form; and as things change very slowly in the East, we may accept the Ramayana and Mahabharata as affording a true reflection of the life and arts of India from B.C. 300, to A.D. 300, or, again, about the Christian era. They give a detailed and vivid picture of the gold and silver plate and metal work, jewellery, arms, trappings, and caparisons, musical instruments, and woven stuffs of the time, but as it is all merely in confirmation of the evidence presented by the "Code of Manu," I will on this occasion reproduce from them but a single illustrative extract; and it shall be from the nineteenth chapter of the second section of the Ramayana. Therein the inhabitants of ancient Oudh are represented as going out in solemn procession with Bharata at their head to seek for Rama. They march forth in the order of their trade guilds, viz.:—jewellers, potters, ivory workers, perfumers, goldsmiths, weavers, woollen manufacturers, curiers, carpenters, braziers, painters, musical instrument makers, armourers, blacksmiths, coppersmiths, makers of images, cutters of crystal, glass makers, inlayers, and the rest of them, with the chief of the guild bringing up the rear. This list of trades is almost identical with that given by Surgeon-General James Taylor, in his "Sketch of the Typography and Statistics of Dacca," published at Calcutta in 1840. It is just such a list of native trades as might be prepared from the latest census returns of any of the great polytechnical cities of India, such as Patna, Lucknow, Benares, Delhi, Ahmedabad, Bombay, or Hyderabad in the Deccan: or compiled from the table of contents of my book on "The Industrial Arts of India." What stronger proof is needed of the unbroken continuity through the past 2,000, and probably 3,000, years of the industrial life of India, and of the consequent subjective identity of the arts practised at this day in India, even in such Mahomedan cities as Ahmedabad and Hyderabad, with those that flourished contemporaneously with the preparation of the final recension of the "Code of Manu," and of the Raymayana and the Mahabharata. The Mahomedan conquest has had its influence on the arts of India; but it has nowhere destroyed their instinctive, and ever immanent, Hindu character, nor has it in the slightest degree affected them beyond the limits of its territorial extension. The arts of Western India have been very slightly modified by it, and those of Southern India not at all. All over India stone carving, wood, horn, and ivory carving, braziery, armoury, jewellery, goldsmithing and enamelling, musical instrument making, weaving, and the manufacture of all sorts of sumptuous trappings and caparisons, are inherently Hindu arts, and quite independent of any Mahomedan inspirations. The "Code of Manu," the Ramayana, the Mahabharata, and the arts of India, were concomitant, and interdependent expressions of the equilibrium gradually established between conflicting races, creeds, and interests in India during the long struggle for supremacy between Brahmanism and Buddhism; and the fact that the caste system is still binding on the Hindus, and that their ancient epics still form the chief part of their living literature, is an incontestable argument in support of the view that their historical arts also are, in all their intrinsic qualities, the same now as they have been from the beginning, notwithstanding the Mahomedan conquest of India. The Mahomedans in India were indeed never either physically or intellectually strong enough to radically disturb the sacrosanct social and economic organisation of the Hindus. They have rather themselves been absorbed into it. Otherwise they would have made as complete an end of the old pagan civilisation in India—the last reservation of antiquity—as in Arabia, Africa, Persia, and Central Asia: for, whether the pressure exerted be that of military or commercial domination, it is impossible to successfully impose foreign ideas and institutions upon any people possessing a civilisation the outgrowth of their own conditions, needs, and aspirations without involving their moral and material destruction as a distinctive nationality, and the entire extinction of their indigenous, idiosyncratic arts. In India it would involve the absolute disappearance of the race, nationality, or society of Brahmanical Hindus; which is the creation of the "Code of Manu."

(To be continued.)

Notes on Books.

BLACKIE'S SCIENCE TEXT-BOOKS. Light, Heat, and Sound, by C. H. Draper, D.Sc.; Magnetism and Electricity, by W. J. Harrison and C. A. White; Geology, by W. J. Harrison; First Mathematical Course. London. Blackie and Son.

These text-books are prepared principally with a view to the requirements of the Science and Art Department's examinations. They are fully illustrated, and contain specimen examination papers. The one on mathematics includes arithmetic, algebra (including simple equations with two unknown quantities), and the first book of Euclid.

PRINCIPLES OF GENERAL ORGANIC CHEMISTRY. By Prof. E. Hjelt. Translated by J. B. Tingle, Ph.D. London: Longmans. 1890.

This translation is made from the German edition of Professor Hjelt's book, which appeared originally in Swedish. It is intended for students who have already some knowledge of organic chemistry. It is arranged in three parts. Part I. treats of the composition, constitution, and classification of organic compounds; Part II. deals with the physical properties of organic compounds, and their connection with the constitution of those compounds; Part III. is devoted to the chemical behaviour of organic compounds.

ELEMENTARY MECHANICS. Blackie and Son.

This little book, which is one of Messrs. Blackie's elementary text-books, gives in simple language an account of the mechanical principles. It is intended for junior students.

General Notes.

THE CHICAGO EXHIBITION. — The *Scientific American* states that a site for the Exhibition has been finally chosen. On the 2nd July the World's Fair National Commission formally accepted the joint site, consisting of the lake front and Jackson-park, as the location for the Columbian exposition, by a vote of 78 to 11.

NEW ZEALAND MEAT.—The *Colonies and India* remarks that the enormous increase in the frozen meat export trade from New Zealand during the past few years must be exceedingly gratifying to all who happen to be interested in the great Antipodean Colony. The value of the exports to the Old Country in 1882 amounted to only £19,000, while in 1887 it had risen to £445,000. Over a million carcases of mutton are now sent annually to England, and there seems to be every prospect that the trade will go on increasing at a similarly rapid rate.

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Proceedings of the Society.

ADDITIONAL LECTURES.

DESIGN APPLIED TO WOOD-CARVING.

By Lewis F. Day.

Lecture II.—Delivered May 8, 1890.

Wood-carving is of no particular time or country. It is a cosmopolitan art, to be found everywhere; but it is most especially an art of the North, of the countries where there are forest trees, long winter evenings and snug firesides, just as marble belongs to the South where it is found.

England has always been famous for its carpentering; and its open timber roofs, enriched more or less with rudish carving, are the admiration of the French—who claim to be far ahead of us in the matter of the more delicate carving of cabinet work and such like. And we may admit that subtlety of execution and delicacy of finish were not precisely our strong points. At the time when the Italian, French, and Flemish carvers were doing very graceful and highly-wrought work, we were mainly content with vigour, energy, effect.

Our earliest wood-carving belongs not to cabinet work but to carpentry.

It is only towards the 16th century that we get fully developed joinery, carved panelling and so on.

Cabinetmaking is an art of the 17th century—then begins the reign of the cabinetmaker and upholsterer!

It is not surprising that the styles of carving should have varied with the centuries, according to the purposes of carpentering, joinery, and cabinet work, and according to the woods employed for those various purposes; the style especially suitable to any one was obviously incompatible with others.

The grain of the wood has, as you know, everything to do with the carving it. One must cut according to one's wood, or the wood will want to know the reason why—and the wood will have the better of the argument, too.

If you would carve to any purpose, it must be according to the grain of the wood—I need not enlarge upon that. What is, perhaps, not quite so generally understood is that the design also must bear some relation to the quality of the material, hard, soft, evengrained, or whatever its character may be.

Variegated woods are plainly (according to the emphasis of the figure) ill-adapted to delicate detail. They only quarrel with it, interfere with its lines and contours, and undo the work of the carver. So it happened that carvers in oak naturally resorted to strong lines and distinct relief, in order that their work might hold its own.

Even in the more beautiful Italian walnut, the figure is sufficient to necessitate a certain boldness of design, and it is perhaps because of the general use of these woods that carving in rather high relief has for the most part prevailed.

And I am rather afraid that to this day there is an idea among carvers, and still more among their employers, that a high degree of finish, and a near approach to the round are necessary to good carving. I would like the student to get rid of such notions.

If he must start with a prejudice, let him rather begin by thinking very slight relief necessary, and still less elaboration of finish. He will arrive quite soon enough, and by very natural degrees, at that point of execution where his art begins to go down hill. His fault is that he wants to start at the end, or at the very least in the middle, of his craft. Let me commend to his attention the beginning—that is the place to begin.

Ambition is no doubt a fine thing in its way (though "by that sin fell the angels") but it is easy to be too ambitious or to be ambitious in the wrong direction, in a direction at all events in which our faculties do not lie.

We are too much disposed to overlook or to ignore the scope there is for carving of a quite rude description; and the professional carver—now that his craft begins to rank as a profession and no longer as a simple craft—looks with too lofty a contempt on all but the finished workmanship which claims to be more or less fine art (Carlyle uttered a wish that the devil might fly away with the fine arts—if he would only fly away with the phrase one would be much obliged to him).

In the days of our less sophisticated forefathers—when it was not fashionable to talk about art—it was quite a common thing, as you know, to ornament the ordinary chests and other objects of household use with simple but not ineffective parting-tool and gouge work.

It is quite possible to attach far too much value to mere elementary surface decoration like that. Amateurs have attached to it sometimes an importance at which the carver, not unjustly, scoffs. But it is decoration, and it is worth having—and it is a pity that it ever fell altogether into disuse. I may add that it is more pity still that it is now being manufactured for sale in shops of some pretensions.

But what is quite incompatible with fashionable upholstery, and quite out of the running as art of serious aim, is just what a working carpenter might take pleasure in doing, as the final touch of decoration to the thing he has been making—and the thing itself should be the more valuable to the person into whose hands it comes for that last touch of the workman. If those who are interested in the "Home Arts and Industries" could but revive that kind of thing in the villages all over the country, they would be encouraging a class of unpretending workmanship which might, in the case of individuals, develop eventually into something worth the name of art.

There are two or three examples on the screen of a quite rudimentary character which are yet, I think, by no means to be despised. They are all I believe English work.

In the chair and cabinet furthest from you you have the very simplest and most obvious workmanship. You can see how the gouge dictated the design. It is rudimentary, but it is workmanlike and effective—and I think it is well worth doing.

In the door panel, in the centre of the screen, you have work still of the simplest, mere surface carving grounded out, but the design is singularly good. As carving, it is not carried far; but it might have been carried further without greatly improving the effect—and for a chair back, of course, you want a smooth not a lumpy surface. Besides people want chairs which don't cost a small fortune.

The objection to anything like rude workmanship, now-a-days, is that it is out of keeping with the greater degree of, polish I was going to say, but shininess more exactly expresses it, which we affect in our domestic furniture.

One would like to persuade people to care a little more for freshness, vigour, individuality, and a little less for a kind of smoothness which is artistically about on a level with the polish on one's boots—but that I am afraid is Utopian.

Other details are from the staircase of the Charterhouse. The carving in this case is most effective, but it is quite coarse in execution. My friend Mr. Aumonier has lent me a photograph of the staircase, in which you will see more plainly the rich effect of the work. Where such effect can be produced by such means it seems to me the merest stupidity to neglect them. The pilaster-like ballusters, and the handsome square-cut newells are characteristically Elizabethan and characteristically wooden. Ordinarily, however, there is a raised margin to each face—and one rather misses it here. Instead of being grounded out, the ground seems rather to have been cut away—and so the carving rather wants framing.

The hall of the Honourable Society of Gray's Inn is another excellent example in point—also lent to me by Mr. Aumonier. Rich as the work is, there is no seeking after refinements of execution. The work all tells—and how telling it is you see. The pillars, you will notice, are carved all over with strapwork, so flat in treatment as not to interfere in the least with the contours; but in that strapwork there is no repetition from top to bottom of the columns. If they were economical of labour in those days they spared nothing in design.

I need not dilate upon the charm of such variety in design.

And though there is in this work nothing but what most men could execute, how effectually the place is decorated! There is an air of comfort as well as dignity about it. One might go much further in ambition—and do so much worse.

There is nothing more effective in design than the carving of the Elizabethan period. More or less affected in design it may be, rude in execution it undoubtedly is, but there is a sumptuousness about it not always to be found in contemporary Flemish carving (with which it has some affinity) nor yet in the much more consummate workmanship of France and Italy.

Whatever objection there may be to rudeness of execution it does not apply to exterior architectural work, such as we see in the timbered buildings of France and Germany, and, in a less degree, at Shrewsbury and Chester.

I showed you last week, but I show you again, a typical example of an old Brunswick house. The detail of the carving is more ingenious than strictly beautiful, but the effect of it is wonderfully rich. And there is something consolatory to the carver who does not aspire to any very high degree of artistic achievement, to think that by such means he can produce such an effect.

In the Hildesheim house-front, which I also show you for the second time, you see perhaps more plainly still how effective the very rudest work may be. This is by no means an exceptional specimen of domestic work as it remains in abundance at Hildesheim. I take it that any village carpenter could soon be taught to execute carving of that description. And what an enlivenment it would be to our villages and country towns if only a small proportion of the buildings were enriched in some such manner.

The village carpenter would of course want looking after even in the rudest work—indeed, the ruder the work the more essential it is to know what you are about in order to produce your effect; but a single competent artist might keep any number of workmen going, just furnishing them with rough designs and instructing them as to the manner of carving. The amateur himself might do the work. If gentlemen of abundant leisure would occupy themselves in that way, instead of carving bunches of fruit and dead birds, for which there is no earthly use in the world, what benefactors they would be to their species.

An exceptionally good example of mediæval or early Renaissance work is the front of the Guild-house of the Slaughterers at Hildesheim—that is about as far as the carver's art then went. The humorous symbolism of the frieze is most amusing when you look into it. But even here you see the very simple lines on which the decoration is planned. It consists of just two broad bands or friezes of rich ornament, supported by broadly-curved brackets, and then the carving of the archway.

The French example from Rouen is more distinctly architectural. It is more carefully thought out in design as well as more skilfnl in execution—but it does not depend upon this for its effect.

From the point of view of the contractor, the day of such work is over no doubt; from the point of view of village industries there should still be the possibility of something of the kind.

It is sad, by the way, to see what Swiss wood-carving has come to. Once upon a time, and not so very long ago, every châlet, about Meyringen and other districts, was vigorously and interestingly carved, sometimes with considerable elaboration, always with considerable effect. Now we have, instead, what is called a thriving industry, a brisk manufacture, that is to say, of sprigs of edelweiss, and chamois, and toy châlets, and such-like frivolities—anything which is calculated not to rise above what the monied tourist calls his taste.

Among the comparatively ruder forms of carving must be included the Gothic, even in its later phases—and its design, as always, corresponds to its execution. At its best it is luxuriant and rich in effect rather than graceful in design or refined in execution.

With every admiration for the energy and earnestness of Gothic art it is difficult for me to understand how even bigotry can blind the partisans of Gothic and only Gothic to its obvious shortcomings in respect to some of the higher qualities of art. And wood-carving is not its very strong point.

No one I suppose would seriously pretend that there is anything in Gothic woodwork to compare, for delicacy of design, subtlety of treatment, and refinement of execution, with the best work of the Renaissance. But there was in it for all that a workmanlikeness and a rightness, a crispness of cut, which the more accomplished workmen of a later period never excelled, and which they often lost in their pursuit of finish.

In Gothic wood-carving there is always the charm of direct and skilful cutting. There is a sureness and an ease about it difficult to over-value. The carver reveals himself by his cut. He was not sophisticated enough ever to stray far from the way in which he should go. Technically it is for this beautiful cut that the carver appreciates Gothic wood-carving and not as exemplifying by any means all that can be done in wood.

A certain falling short in the matter of finish only concerns us, however, inasmuch as it affects the design. I think the elaboration and intricacy of detail that we often find in Gothic carving has some connection with it.

Design and execution act always, and react, the one upon the other. In a maze of rich detail the eye does not seek sublety of finish, nor detect roughness of execution—whereas, a simple shape, clear cut against the ground, compels some sort of finish because, so seen, nothing less will satisfy the eye.

A more serious fault in Gothic carving is that its aim was to some extent misdirected.

The idea of properly framing woodwork had not yet freely developed itself and we find accordingly the familiar forms of stonework repeated in wood, to which they are in many respects not altogether adapted. There may be positions in which it is desirable to reproduce in the woodwork architectural forms which belong by rights to masonry; but except for some special purpose, as an expedient of design, it is not the kind of thing that commends itself to the thoughtful mind.

In the face of some really beautiful examples of wood tracery, for example, one is quite willing to admit that there is room for such work in wood; but to depend upon it, would indicate I think a certain lack of invention in the designer. It is a device to be adopted rather for the deliberate purpose of what I may call architectural sequence, or of subduing the interest of particular sections of the work in order to enhance the value of others. Used to any very large extent it becomes monotonous in effect, and is not sufficiently interesting to justify the expenditure of so much labour upon it. That is to say the same amount of work expended on some other form of ornament would tell to much greater advantage.

There is a German cabinet on the screen with doors ornamented with panels of geometric tracery which to my thinking are not important enough for the place. It is all very well on the feet (where it also occurs) but on the four central panels it is almost as foolish as the little trellis diaper on the drawer fronts. This is all the more noticeable because the foliated carving is in its way—a characteristically German way—exquisite, and most skilfully adapted to wood; you can see the scoop of the gouge all through it, and it was clearly designed with that view. But that trellis-work is a stupid waste of labour, and the tracery is scarcely less so—in that position.

You cannot get over such waste of labour by simplifying the design of the tracery. For the effect of such tracery depends almost entirely upon its elaboration. You can see that pretty plainly on the screen where I have arranged sundry panels in something like progressive order. The simpler Flemish examples are comparatively tame. The two French panels, nearer this way, are more interesting exactly in proportion as they are more intricate in design. The single panel below, with the *fleur de lis*, begins to be really amusing. And in the still more flamboyant chest-front, nearer to you, also with *fleur de lis* in the panels, you may see what may be done in the way of really delightful tracery in wood.

I would like to digress one moment to call your attention to that little bit of cresting at the top of the screen—to my thinking a perfect bit of simple downright work, accomplishing all it means to do. All these examples, I should say, are at the South Kensington Museum.

With regard to the setting out of such tracery, I have a very determined conviction, not only that it must be tolerably intricate (smaller work of course contrasting with bolder, but still producing a rich effect all over, without conspicous gaps or patches of baldness) but that it should not under any circumstances be mechanical in execution.

I am not advocating the other extreme of "sketchiness" or suggesting that the two sides of a would-be symmetrical form should be perceptibly unequal. They should, on the contrary, be as equal as the carver can draw them. And he should spare no pains to get them true. In fact, he should get them as true as he can without reliance upon mechanical contrivances—that is to say, the forms should be drawn, not struck.

There is no denying that it is quicker to strike circles with a bow-pencil than to draw them freehand; or that they are more precisely accurate when struck than when they are drawn. But there are two objections to striking. The first is the inevitable hardness which results from geometrically struck lines, and the second is the constraint which the instrument imposes upon the invention of the artist.

It is quite clear that in designing freehand you are much more likely to get freedom, and variety, and flow of line, than when you let the instrument suggest the direction of the sweep—as it must do if you design always compass in hand. Convenience, great convenience, there may be in the use of form which a machine can mechanically reproduce; but that is a question apart from art.

It has been contended that the subtlest curves can all be reduced to geometric construction. That may or may not be so. It is possible that there is something in the nature of naturally graceful lines which enables them to be accounted for geometrically. But that would not prove that they were so designed—for my part I don't for a moment believe that the subtler elliptical forms of Greek art were arrived at first by conic sections, or that really beautiful tracery was ever inspired by bow-pencil.

The Germans have a style which may justly be called geometric (it is as hard as mathematics) and our own Perpendicular style seems sometimes to owe more than it should to the T-square; but the beautiful flamboyant tracery of the French came straight from the brain of the artist, modified only by the hand that drew it—that is quite clear on the face of it.

With the bow-pencil you make circles and little circles and segments of circles; with a free hand your fancy has free play, and your lines take the form of flames or *fleurs-de-lis*, or whatever may seem to you to meet the case.

The simple plan I should advocate, not only with regard to tracery, but to geometric shapes in design generally, is this. I should first of all sketch in freely, as it occurred to me, the effect I wanted to produce. I should then, and then only, set out mathematically the obvious geometric divisions into which the lines fell; and, having thus set out the framework or scaffolding of my design, and such radiating or other help lines as might assist me in subdividing, cusping, and so on, I should then draw in, firmly and finally, without further recourse to mechanical instruments, the details of my design. I should spare no pains to make my circles as round as my hand would make them, but I should think much more of balance of line and sweetness of curve than for mere geometric precision.

The supplementing geometric work by foliation more or less (such foliation occurs in two of the examples shown) is a matter of some delicacy. It wants doing judiciously. Such foliation must always be so far removed from nature as to be in keeping with the arbitrary lines with which it is associated. Natural foliation would make them look harder than ever; and the thing to beware of in tracery is, once more, hardness.

A great part of the more imposing (if not the more important) wood-carving of the Gothic period occurs in the form of canopy work over cathedral choir stalls.

My friend Mr. Aumonier has been good enough to lend me a photograph of the stalls at Chester, a typical and admirable example of English work, which you may compare with the more famous French work in the cathedral at Amiens—which I will show you to follow it.

Of the richness of such carving as that there is no manner of doubt; but it hardly comes under the category of practical wood-carving; it is essentially architectural, if not absolutely architecture; and, so far as design is concerned (and it is design which is under discussion in these lectures) it is the business rather of the architect than the sculptor. I take it no church-architect of the present day would leave the design of his canopy stalls to the carver; but would give him precise working drawings of every detail, and so relieve him of the responsibility of design.

What strikes me about it, when it is done, is that, for all its richness, something much more intrinsically interesting might have been produced at less cost of labour than all that quasi-architecture—after all only the reflection of forms more essentially belonging to, and proper to, stone.

Not but what such canopy work has often distinct merits of construction — apparent enough in the examples shown. It is put together with great skill and judgment; but it is the skill more particularly of the joiner; and we may look upon such work rather as triumphs of joinery helped out by carving, than as specimens of wood-carving proper.

Perhaps the most practical thing in the design of Gothic woodwork is what is known as the linen-fold pattern, too familiar to need illustration. But that again is not so much wood-carving as an expedient by which the joiner gets out of his plane something which with a little assistance from the chisel almost supplies the place of wood-carving. *Quâ* imitation, nothing could well be more absurdly inappropriate to the decoration of wood panels than what is known as linen-fold. But I take it that imitation is not its starting-point at all, but only an after-thought—one of those second thoughts which is not best.

It grows, as said, out of the use of the moulding-plane. If you want to disturb the even surface of your panels pleasantly and without much pains (was there ever a time when men did not want to save themselves trouble?)—if you want to break the plain surface of the wood pleasantly, the simplest thing to do (having a plane at hand, and vertical lines being architecturally of some value) is to plough along a plank with the plane and cut it into the lengths determined by your framing.

The objection to this proceeding is, that at the ends of the panel the moulded ridges would abut awkwardly against the mouldings at top and bottom; that is to say any ordinary moulding would not intercept them at all happily; they would require a square member of quite inconvenient depth to stop against. The difficulty was got over by working down the ridges at each end to the level of the ground.

In endeavouring to disguise the bald section of the ridges and soften the lines into the ground, the artist was struck by some resemblance of the section to the overlapping folds of linen, and he proceeded to carve a more or less fantastic representation of the edges of a folded napkin. But the more fantastic he made it the better—the more he thought about grace and interest of line and the less about linen, the more his design commends itself to our respectful consideration.

And, as a device for helping out with a minimum of carving work essentially mechanical, that manner of work deserves perhaps much further development than it has yet received at the hands of a generation priding itself upon its practicality. Once more I have to put in a good word for design which does not pretend to much. I do so because our modern work is given so much to brag.

I have two or three more specimens of Gothic carving to show you.

The pierced panel (the top one on the screen) is a quite typical bit of German work—there is a mutilated example of the same kind of thing at South Kensington Museum, which Miss Rowe is reproducing in the photographs she is editing—and there is a little thistle panel at South Kensington of about the same period. This is very broad, effective, carver-like carving.

The panel below it is exceptionally delicate of its kind.

The chest at the bottom of the screen is rather florid and confused—more elaborate and less satisfactory.

The detail of the ornament in the central panel of these three is not unlike that of the more delicate one of those last shown; but it is here no longer meant for foliage, but for mantling from the helmets surmounting the shields of arms. The fact is that in each case the artist was thinking much more about ornament than about foliage or mantling—and very properly so, too. You will notice the flatness of the lions supporting the shields. That is not because the carver couldn't make them rounder. The man who designed those lions knew the value of breadth, and was careful not to fritter it away.

Next you have four more heraldic panels. It is interesting to see how the lock encroaches on the panel and gives an irregular space to be filled. The two panels nearest to you are comparatively monotonous in their design—they are too all-overish, scarcely of more account than a mere diaper would be. The other two are much more effective—in fact the upper one of the two is exceedingly fine. Gothic work does not go much further than that. The photograph is unfortunately fading away; but it shows perhaps none the less clearly for that how skilfully the designer planned his shadows. I shall have more to say about that presently. Enough to note here the vigour both of design and execution.

And as to that same roughness, just now spoken of. Vigour will excuse roughness: only refinement will justify smoothness. The thing is to get vigour first, both in design and execution, and finish only so far as you can refine upon it.

The more you do the more you should be telling in your work. When you have said all you know, then it is time to stop. It is of no use going on merely to make it smoother: that is not "finish" but mere frivolity and feebleness.

Least of all should you labour to efface the mark of the tool. Where the mark of the tool interferes with what you have to say, disturbs the effect you are aiming at—out with it, by all means: otherwise, there is not only no harm in it, but absolute charm. It is by his cut and the skilful treatment of his surfaces that a man shows his mastery over his craft, a mastery not to be acquired without years of practice. Why, then, wipe all that out?

The student must not suppose that he has any business to go dashing away, with the idea of showing his dexterity—he is far more likely to show his incompetence. Early practice must be painstaking. You will find that the boldest manipulators began by handling their tools with extremest care.

What you have to do is to aim at making your cuts right always as far as they go, so that you can leave them if they go far enough. You don't want to reckon much on any final process of finishing—the less "cleaning up" there is to do at the end the better.

The smooth appearance of much modern work is due partly to popular prejudice (the prejudice of ignorance of course) in favour of a sort of smug respectability—there is a dash of Bohemianism in workmanlike frankness—and partly it is due to the desire on the part of the workman to disguise the feebleness of a niggling touch.

No great harm is done perhaps in his particular case, because, he having no appreciation of the character of the wood, no knowledge of its capacities, no grip of his tools, the marks of his cut would tell us nothing but what we can see in the carefully rasped surface so dear to him—to whit his incapacity.

The real mischief is that the patron, the purchaser, the representative of that demand by which supply is regulated, he thinks this finish, prefers it, asks for it, is prepared, perhaps, to pay more for it than for really skilful and artistic work which is to him simply rough.

Let me show you a couple of examples of what I mean by cut. The uppermost of those two instances is from Pistoja. It is Renaissance of course—but the Renaissance is native to Italy; and it is contemporary with our later Gothic. There is a certain rudeness about it which we should call Gothic. Notice the simplicity of the treatment. That twist of the neck of the creature is quite sufficiently rendered—but how simply! with how few cuts! how square the modelling is! Nothing could be simpler or more direct in execution.

The panel below shows how that same directness of workmanship may go with a much higher degree of finish. It is one of the panels from S. Severino at Naples (of which I showed you some bench-ends last week—and is of course a century or so later in date). If I had to choose one example of how wood-carving should be done I should choose that. It has all the merits of the work above without any of its crudity. It hits exactly the mean between breadth and finish.

Carving of course may easily be too rough, but the temptation nowadays is not that way, but in the direction of ultra-smoothness; and for that reason it is necessary to insist upon the virtue of crisp and vigorous handling—just as it is necessary to preach simplicity of design because of the tendency of demand in the opposite direction of finnikin elaboration.

We must not flatter ourselves that because our modern work is less *naïf*, less wholehearted, more sophisticated than the old, therefore it is any more finished or refined. The carver offers nowadays for the contract, but there is in the contract no item of tenderness. The touch of nature and of art which would make carving sympathetic becomes accordingly everyday rarer. It is seldom, comparatively, that the carver tells you in his work anything of himself, talks to you, as it were, confides in you—he has no time to gossip over it.

But this is sentimental—let us be practical.

In designing for high relief what you have to consider is the shadows. They are the important factors: it is they that give the relief you want to get. In so far as you want the design to "stand out," you have to be very careful how you break it up with surface carving. It is only to soften the brutality of too harsh a contrast between two surfaces, that you carve the face of your design; you want to get some shadow into it, to connect it more or less with the ground.

As a matter of experience, we find that the surface is usually carved too much. Scrolls, flowers, leaves, are all too full of detail, too much cut up, broken with shadows which only confuse the effect: grace of line and breadth of mass are both lost,

We are inclined to take it too readily for granted that details must be "worked up." We ought to look, and think, before we jump to any such conclusion. I am not overstating it when I say that no detail should be put in without our asking ourselves whether it will help the effect—it is quite as likely to interfere with it.

You want high relief for the sake of high lights—to carve the surface is to kill the light, and so defeat your end.

A design has to be considered as such light on such dark, softened by such and such intermediate tints. According as you want a portion of it to go into shadow you carve its surface, scoop shadows out of it: the broad lights you must keep carefully free from detail.

Only as you bear in mind these distinctions of light and dark and middle tint, and cut accordingly, or abstain accordingly from cutting, only so is it possible to preserve that simplicity and breadth which are all-important.

The shadows being the means by which you give relief to your carving, you must give them their full value and abstain from a multiplicity of minor shadows competing with them. You must be more than chary of indiscriminate shadows - that is the danger you have to avoid.

This is in high relief.

In low relief line is the more important consideration.

And it strikes me always as matter of regret that there is comparatively so little carving in low relief; especially when you think how appropriate it is, how almost indispensable low relief would seem to be, in household furniture, and all that comes immediately under our hands.

There has been very delicate work done in low relief—more especially in ebony—there is a cabinet at South Kensington very elaborately carved in relief as slight as in cameo-cutting—and our inveterate preference for more emphatic projection comes partly no doubt from the woods we use. The coarse grain of oak or American walnut demands, as already said, a certain brute force in the carving to dominate it, or it would assert itself at the expense of the too delicate and subtle modelling. But there is still much more scope in cabinet work for such subtlety and delicacy of contour than we seem to realise; and if ebony and boxwood are so costly as to be unavailable we have pear tree to fall back upon.

I have one example of low relief to show you. It is from the church of S. Maria in Organo at Verona, where it is associated with most beautiful inlay. That central pilaster, and the two half pilasters, are about as delicate as work can be. As a matter of design, the bird and lizard are perhaps rather too natural for the quite conventional foliage among which they find themselves; but from the point of view of delicate and graceful relief there is nothing to be said except in praise of its daintiness. There is room for more such work.

Another reason for our coarser practice may lie in the difficulty of such abstract rendering as is implied in low relief—a difficulty never enough appreciated by the public, who are always impressed by the actual relief of nature as something vastly clever.

When we consider that, so far as cleanliness, convenience, and softness to the touch, are concerned the relief of carving in cabinet-work cannot well be too low, there appears to be something peculiarly impractical in our Philistine preference for whatever "stands out."

Even coarse-grained wood allows of much greater delicacy than is shown in our treatment of it. And, there is another thing, because it is so easy to get relief in wood, that is no reason why the relief should always be as high as possible; because it is so easy to undercut in wood, that is no argument for forcing every detail into relief by the darkest possible shadows.

Wood lends itself so readily to undercutting, that it would be foolish perhaps, a neglect of our opportunities, not to avail ourselves duly of the facility. (In marble, for example, if you undercut very sharply you get reflected lights in the hollows, if not transmitted light, so that the shadows are not so sharp as if the edges of the carving had been sunk at something like right angles to the ground.) A certain degree of undercutting, then, is desirable; it goes to make the work look like wood; but the more reticent you are in its use the more effective it is when you do resort to it: you get emphasis then just where you want it. There is no occasion to speak always at the top of your voice, and it is a sure sign of inexperience so to shout.

In a design carried to any degree of elaboration or finish, there should always be parts which, so far from asserting themselves at all, lose themselves, die away into one another, or into the background. The more important features thus gain special prominence, and the composition groups itself together as a whole. The carving seems thus to grow out of the wood and not to be planted on to it.

If you cut your composition up into what a friend of mine calls a mere "arrangement of chips," there seems no very valid reason why such chips should not literally be carved separately and stuck on.

The obviously practical way of designing wood-carving is to start with the deliberate purpose of making the most of the surface of the wood; to make nothing of it seems to me the mere perversity of design. I cannot see how any reasonable person can lose sight of the necessity of getting his effect at a reasonable cost of labour.

Don't understand me to mean that carving should be mere surface work just grounded out, although, as I have said already, opportunities in that simple way have been too much neglected. Having grounded out your design you naturally want to vary its surface, in fact to carve it. But if you carve it nearly all down to the ground, and leave only here and there a boss or two projecting, such projecting features have all the appearance of having been applied—and one hardly sees why they should not be applied. Was it worth the pains of cutting away so much wood to so little purpose;—it may have been—but was it?—that is the question we have to ask ourselves in each case.

I don't know whether the central knobs in the upper door panels on the screen are carved out of the solid or not—I don't see why they should be, and if I wanted those knobs (doubtless the designer felt that he did want some such high note there) I should have made them by preference in bronze or something that would allow me frankly to acknowledge that they were added to and not cut out of the panel.

That panelling, by the way, many of you will recognise as being now at South Kensington Museum. It comes from a house at Exeter, but I am not quite so sure of its being all English work. Anyway it is very nice work, and worth study both for its varied design and for its unaffected execution.

I have already alluded to the panels of the so-called Spanish cabinet which to me lose something of their charm as being less obviously adapted to wood carving than to modelling—they would have been perfect in clay or plaster—but the carving is here essentially part of the panel, and does not look as if it were stuck on. I am afraid you can hardly see the cut of the carving; but it is admirable.

The dying away of your design into the ground, somewhere, is almost necessary to prevent the unfortunate appearance of its having been stuck on. And, once more, in the case of every outline being undercut, and the ornament all in sharp relief against the ground, one is almost tempted, not only to think that it is *appliqué*, but to ask why not.

The danger of one prominent projection seeming not to belong to the panel is lessened, as I explained last week, by associating with it in the composition other features only less prominent, and with these others again more plainly connected with it—so gradually preparing the eye for what would otherwise be something of a shock.

The suggestion that carving should die away into the ground pre-supposes some ground showing into which it can die. It is a common fault in carving to leave too little ground. That is a very common fault in design generally. It is always easier to cover a space than to occupy it: it is only as we attain to something like mastery of our craft that we arrive at simplicity, and realise how little will do, and how much more to the purpose that little is, so it be good and in the right place precisely, than more work would have been. As we progress in design we put more brains into our handiwork and less labour.

In designing for wood-carving the danger of overcrowding is greater than ever. It takes you some time to realise what a quantity of clear ground wood-carving will stand—if it does not absolutely require it. A design that would be simple enough in marble will appear quite busy in wood; and what would be bald in white stone will appear just dignified in wood.

We are always croaking about economy. If we were only wisely sparing of our work we should perhaps be able to devote to it time enough to do it decently well.

A word as to the ground itself.

The effect of the ground in relation to the carving must not be lost sight of. It is too readily assumed that the more absolutely level you can get it the better. That is not so, by any means. Such mechanical evenness only makes it look, once more, as though the carving were applied on the already smooth surface of the board or panel—bears false witness against it, so to speak, and takes away its good character as carving.

The router and the riffler may be very useful servants—I will take the carver's word for it that they are—but let them keep their place. So far as the mere preparing of your work is concerned I don't see why you should not use any appliance that may assist you, no matter how mechanical. If you had a considerable surface to get down round some single projecting mass, you would naturally use the saw, or the plane, or whatever would expedite matters, and give you more time for actual carving—and so with the router and the riffler, if they will do the drudgery, well and good—but when it comes to finishing the ground, absolute evenness not being desirable, and the mark of the gouge having a distinct interest of its own, the more mechanical appliances cease to be artistically available; and the evidence of their use becomes an eyesore. One might apply the Spartan principle and say there is no harm in using mechanical helps, only you mustn't be found out. If the router betray itself you have misused it.

There are various ways of "finishing" the ground. I confess to liking the tool marks left pretty plainly; they give a texture to the ground which contrasts well with the more finished surface of the carving.

The panel from S. Angostino, Perugia, which is very beautifully carved, shows plainly the intention of the artist in leaving his ground so. You have there a panel and an elevation of part of the choir, showing how the panels occur. The way the objects are piled together, so to speak, in the panel is not quite according to my idea--though the design is attributed (falsely of course) to Raffaelle. But the carving is quite exceptionally good, and the treatment of the ground, showing the tool-marks, most judicious.

Another common way of arriving at contrasting texture is to stamp or punch the ground with dots or what not. This plan of dapering was freely adopted in old work. It occurs in the panels I showed you last week from S. Pietro, also at Perugia, but notably different in character from the work last shown.

Punching, I must confess, always seems to me rather a cheap way of getting over the difficulty, and not especially characteristic of wood except of the very softest kind. It is obviously much better adapted to plaster, leather, or metal, than to hard wood at all events. If I were working in gesso or other such soft composition, I should probably punch the ground: I should abstain from punching a wooden ground lest it might suggest something of that kind.

Apart from the texture of its finish, there is of course no reason why the ground should all be precisely on one plane—quite the reverse. By slightly raising it here, or depressing it there, varying ever so slightly its depth and perhaps its angle, you get a certain quality which is to a mechanically flat surface what a wash of colour is to a dead tint, of which no artist would spontaneously be guilty.

I have a lively recollection of some carving that I saw in Paris in 1878 from Cochin China. It was on two planes. That is to say the ornament was in fairly high relief on a sunk ground, which again was patterned over with surface carving. This relieved its evenness; and the broken texture produced by this minuter detail contrasted perfectly with the broader surface of the carving in bolder relief. Something of this kind might perhaps be worth our doing, even commercially speaking: it would hardly be more laborious than carefully bringing the ground to a perfectly even surface; and it is so strikingly rich in effect that one might ask, and get perhaps, a fair price for it.

For those, moreover, who will have infinite variety of surface, and yet would fain preserve some breadth of effect, it offers at least a possible solution of the difficulty.

Miscellaneous.

THE INDUSTRIAL ARTS OF INDIA.

By Sir George Birdwood.

(Continued from p. 792.)

We pass now to some contemporary foreign records of ancient India. Apuleius [b: A.D. 130], in the "Florida" [vi], speaking of the merchandise of India, mentions besides its "heaps of ivory," "harvests of pepper," "bales of cinnamon," "mines of silver," and "streams of gold," its immemorially famous "tempered steel." The "Periplus of the Erythræan Sea," which belongs to the 1st century A.D., states that Opone, south of Tabai, near Cape Gardafui, imported from India, beside rice, *ghi*, sessamum, and sugar, "cotton, woven, and for stuffing," and "sashes;" that Moosa, near Mocha, imported from India, beside saffron and turmeric, "purple cloth," "quilts," "muslin," "sashes," and "apparel made up in the Arabian fashion; that Omana imported beside teak, blackwood, ebony, and horn, "brazen vessels;" that Barbarike, corresponding with Karachi, imported from Western and Southern India beside topazes, "very fine cottons," "glass vessels," and "gold and silver plate;" that Baroach, in Western India, imported beside saffron, spikenard, *rusut*, long pepper, and agates, "cottons of all sorts," "mallow-coloured cottons," and "silk thread;" and that at Masolia, the modern Masulipatam, "a great quantity of the finest muslins were made." Now what had such a country as India was, at any time between 300 B.C. and 300 A.D., to learn in the way of industrial arts, from its barbarous Mahomedan conquerors? Mr. Clarke has told you that they established the manufacture of chintzes at Masulipatam, but we learn from the Periplus that Masulipatam was the seat of cotton manufacture from at least A.D. 1; and it probably had a trade in these stuffs with the Persian Gulf and Red Sea long before that. Indian muslin, described under the name of *sindhu* as a "vegetable cloth," is mentioned, as Sayce has shown, in an ancient Babylonian list; and the *σινδών* of the Greeks, generally translated "cambric" [linen], is now recognised as having originally been the denomination of a very fine Indian cloth, and therefore muslin. In the descriptions, in the Book of Esther, of the palace of Shushan* in the passage [ch. i., v. 6]:—"Where were white, green, and blue hangings," the Hebrew word translated "green" is *karpas*, which is the Sanscrit *karpasa*, "cotton," and the passage should be translated:—"Where were hangings of [Indian] cotton, [dyed] white and blue."

It is indeed difficult to exaggerate the antiquity of the commerce of India with the West. Schliemann found carved Indian ebony in one of the mounds of the Troad identified by him with the site of the city of Troy. Indian teak beams have been found among the ancient temple at Mugheir, *i.e.*, Ur of the Chaldees; and the only question is whether they formed part of the original Akkadian temple built 20 centuries B.C., or of the temple as restored by Nebuchadnezzar the Great in the 6th century B.C. Cotton and indigo, and coffins of Indian tamarind wood, have been found in the Egyptian tombs of the 18th Dynasty, which reigned about the 15th century B.C. Eutychius of Alexandra mentions that Noah's Ark was built of wood called *saj*, which is very like the Indian name of teak wood, *sag;* and the *gopher* wood of the Bible may, in view of the presence of teak wood in the temple of Ur, refer after all to teak. The oldest known and most celebrated articles of ancient commerce mentioned in the Bible, such as bdellium, sweet cane, aloes wood, spikenard, and costus, are all products of India, or Further India. The best spikenard was called by the Greeks *νάρδος πιστικός*, and this word *πιστικός* has hitherto been supposed to mean "genuine," *i.e.*, Indian. But it is now held to have been primarily a corruption of the Sanskrit *pisita*, "fleshy." Homer mentions *κασσίτερος*, *i.e.*, "tin," by its Sanskrit name *kastira*. The Greek for pearl, *μαργαρίτης*, in Latin "margarita," is the Sanskrit *maracata;* and the Greek for ivory, *ἐλέφας*, the Sanskrit *ibha*. Similarly the Greek for rice, *ὄρυζα*, is the Tamil *erisi* [in Arabic *aruz*], and the Greek word beryl [*βηρυλλος*], is the Sanscrit *vaidurya*, *i.e.*, "of Vaidura." The domestic fowl is a native of India and Further India, and already the cock is mentioned by the Greek elegaic poet Theognis, B.C. 544, and sculptured on the "Harpy Monument," now in the British Museum, of Xanthos, dating possibly from the 7th century B C. These now familiar birds had reached Britain by the 1st century B.C. The peacock, also a native of India, was known to the Athenians of the time of Aristophanes, B.C. 427; but the orator Antiphon, *circa* B.C. 440, is able to describe its first appearance among them. It was probably part of the spoil taken by Pericles at the sack of Samos, where it must have been kept in the Heræum from at least the 6th century B.C. It was imported from Southern India directly to Jerusalem by King Solomon, *circa.* B.C. 1000, under the Tamil name of *tokki*, in the Hebrew plural form *takkiyim*. It must always have been an article of Phænician import into the Mediterranean, as shown by its western names—in English pea-cock (cf. Po-cock), in Anglo-Saxon *pawa* (pea-fowl), in Latin *pavo*, in Greek ταως, in Aramaic *tâwus*. Its brazen image is still worshipped, under the name of Malik *Taus*, "King Peacock," by the Yezidis about Mosul (Nineveh).

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* Shusan means "lily," and *sosni* is the name of the Indian quilted bed-covers, embroidered with "lilies." *Sosni-rang*, literally "lily-colour," is the purple of the Iris.—*Geo. B.*

Similar items might be multiplied, but enough has been said to conclusively vindicate the high antiquity of the Indian trade, and the independent origin and perennial vitality of the historical art handicrafts of India. In short, the natural and artificial productiveness of India have from time immemorial been the mainspring of the commercial activity of the Old World; and the export trade of India, as described in the Periplus, and indicated by the monuments of Mesopotamia and Egypt, and by the Bible, Homer, the "Code of Manu," the Ramayana and the Mahabharata, remained absolutely unchanged until it was revolutionised by the introduction of steam weaving into England.

The great development of the ancient international commerce of India took place between the 7th and 6th centuries B.C. and the 6th and 7th centuries A.D, and is almost coincident with the millennium of Buddhistic ascendancy in India. On the rise of Mahomedanism this commerce gradually became more and more disorganised, and as it failed Buddhism also declined, and India reverted to Brahmanism, the reactionary Brahmans driving the Buddhists out of the valley of the Ganges into Southern India, beyond the Kistna. The Mahomedans first invaded India in the 7th century A.D., but it was not until the end of the 13th century A.D. (1294) that they first crossed the Narbudda into the Deccan; and to the last—except during the brief usurpation of Hyder Ali, and his son Tippoo Sultan—the Hindu kingdom of Mysore, representing the great mediæval Hindu kingdom of Bijanagar or Narsinga, retained its independence; and here, and generally throughout the Madras Presidency, the ancient arts of India still maintain the characteristics by which they were distinguished during the Buddhistic period. And everything in Southern India, from the ground plan of the temples to the jewellery worn by the women, carries us directly back to Assyria and Babylonia as the original sources of the "incunabula" of the arts of India. The predominant decorative types of Southern India, Further India, and the Indian Archipelago are all Mesopotamian, and only those of Northern India reflect the reaction of Greece or Asia—first, directly, through the conquests of Alexandria and his successors; and next, indirectly, through the so-called Saracenic art of the Mahomedans. But everywhere the hereditary skill of the Hindu handicraftsman, transmitted through 3,000 years, has assimilated to his own nature every foreign motive and type, and even style, that has passed under his transmuting manipulations.

It will be remembered that about the 8th century B.C. Assyria also began to influence the arts of Greece, which previously had received their chief inspiration from Egypt, and contributed to them several decorative types, but without, in the end, in the least affecting the integrity of their marked local characteristics. Only in their slow and broken passage overland westward these Mesopotamian types lost much of their symbolical meaning, whereas they retained it unimpaired in their direct transit by sea to India; and that they have preserved so much of their primæval significance to the present day is for me the chief charm of the arts of India.

LENGTH OF RAILWAYS IN EUROPEAN COUNTRIES.

A French statistician has recently compiled a statement showing the length of railway lines in the various countries in Europe, on the 31st December, 1887 and 1888, and the extent of new lines opened during the latter year. The following is the statement in question, the length being stated in miles instead of in kilomètres (as in the original return), the kilomètre in each case being taken as equivalent to ·621 of an English mile :—

Countries.	Length of Railway Lines.		Increase in 1888.
	Dec. 31, 1887.	Dec. 31, 1888.	
	Miles.	Miles.	Miles.
Russia and Finland	17,709	17,769	60
Sweden and Norway ...	5,558	5,644	86
Denmark	1,223	1,223	—
Netherlands..................	1,833	1,863	30
Belgium	2,908	3,028	120
Germany	24,589	25,196	607
France	21,255	21,887	632
Switzerland..................	1,691	1,747	56
Spain	5,894	6,004	100
Portugal	1,136	1,188	52
Greece	376	388	12
Italy	7,197	7,670	473
Austria-Hungary	15,342	15,981	639
Turkey, Bulgaria, and Roumelia	865	1,024	159
Malta	7	7	—
Servia	321	321	—
Roumania	1,460	1,537	77
United Kingdom	19,578	19 812	234

A NEW MEXICAN TEXTILE.

The Belgian Legation at Mexico has recently reported to the Belgian Government on the subject of *guimbobo*, known also as *angu*, which is found in the State of Vera Cruz, a plant which should be included in the category of all the varieties of Mexican textiles. An American specialist has been appointed to examine and report upon the fibre-producing qualities of this plant. This gentleman has discovered that the *guimbobo* or *angu* produces not only a fibre of very superior quality, but that it can be easily and cheaply cultivated ; moreover, the fruit of the plant constitutes a nutritious food. It appears from experiments that have already been made that the *guimbobo* differs essentially from the ramie, cotton, and hemp, as in the *guimbobo* the covering of the plant surrounds the fibre, and is not mixed up and interlaced with it ; this constitutes a decided economy, added to great facility, in extraction und utilisation. The structure of the plant permits of the operations of separating and removing the bark being performed by machinery, while in the other fibrous plants these operations must be effected by hand, a system at the same time very costly, and only possible in countries where there is a large number of hands available and cheap. It is stated by the American specialist that he could construct a machine, costing no more than the ordinary machines used for cotton, and which could be used in the same manner. By this machine the fibre could be extracted and sold by the pound in the same way as cotton. Persons cultivating this plant would benefit in addition by the sale of the fruit, which is much esteemed in the temperate and tropical countries of the South, where the *guimbobo* grows lururiantly, and almost without any care. The fibre of the *guimbobo* has a lustre similar to that of silk, and is undoubtedly finer and stronger, with a creamy colour between white and straw colour.

General Notes.

Diamonds in Australasia.—It appears from a publication receently issued by the Government Statistician of New South Wales that many descriptions of gems and gemstones have been discovered in various parts of the Australasian colonies, but no systematic search has been made for any but the diamond. Diamonds are found in New South Wales, Victoria, and Queensland, but only in the first-named colony have any attempts been made to work the diamond drifts. The principal diamond fields are situated at Bingera, near Inverell, in the New England district. The Government of New South Wales has, on various occasions, obtained the services of experts to report upon the fields, as well as the gems which have been from time to time extracted from them, and these reports, it is said, have generally been of an encouraging nature. The number of diamonds found in the colony to the end of 1887 is estimated at 75,000, the largest one being of $5\frac{5}{8}$ carats, or 16·2 grains. The diamonds occur in old tertiary river drifts, and in the more recent drifts derived from them. The deposits are extensive, and have not yet been thoroughly prospected. The New South Wales diamonds are harder and much whiter than the South African diamonds, and are classified on a par with the best Brazilian gems. During the year 1887 the diamond companies at Cope's Creek, near Bingera, produced about 23,000 diamonds, weighing 5,151 carats ; but in 1888, owing to the severe drought which occurred, the search for diamonds had to be temporarily abandoned.

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ADDITIONAL LECTURES.

DESIGN APPLIED TO WOOD-CARVING.

By Lewis F. Day.

Lecture III.—Delivered May 15, 1890.

I have still a word or two to say, which time did not allow me to say last week, on the "cut" in carving.

Why, it is asked, should anyone care to see the mark of the tool? Why does the artist insist so much upon that?

Mainly because he can tell at once from that what manner of workman the carver is. It tells at a glance what he knows and where he hesitates. And if he knows what he means to do, and can do it, every cut he makes is interesting, inasmuch as it reveals that knowledge and that power. A craftsman sees in your work, as plainly as if you had told him (you *have* told him, though not in words)—he sees that you felt that line, that your gouge followed your impulse there and there (as though it must be so, could not be otherwise) and was only interrupted by the physical impossibility of crossing the grain of the wood at such or such an angle.

If the cuts you leave are not interesting—want disguising by a process of smoothing, it is because they show no such mastery of hand, but indicate rather a feeble feeling your way, excusable in the student, but not much to his credit.

The beginner must not suppose that I mean him to affect a slap-dash sort of manner, or to try and make it appear as if he knew all about it when he doesn't; but that he should try always to cut with intelligence and precision. (He should by rights also acquire the habit of passing the mallet to the other hand, when the grain of the wood renders it desirable—as it often does. Charles Reade used to contend that everyone should be taught to use both hands alike—the carver who has learnt to do so has certainly a considerable advantage over those who have not.) If the only respectable surface you can get is something perfectly smooth and characterless—so much the worse for you. Anyone can tease wood into something like the shape he wants, and then smooth out the evidence of his niggling. But if a man wants to master his trade he must set to work to acquire a cut he need not be ashamed of, and the marks of which he need therefore be at no pains to obliterate.

Wood-carving has first to look like wood: and this holds good with regard to design as well as execution. If, to this end, natural form, natural effect, must be more or less modified, or even sacrificed—so be it. In art, and especially in applied art, nature takes the subordinate place.

The violation of artistic propriety is not to be condoned because the offence was committed in imitation of nature. Whatever inspiration we may get from nature, the wood-carver must not go to her to teach him treatment—that must be according to the nature of wood, and not according to the growth of this vegetable or that.

In all decorative art we look for, and we must have, a certain breadth of treatment, with which the actual imitation of natural form is in great part incompatible. We all admit the charm of nature—it is because of her fascinations that the artist needs to be on his guard. If he would remain faithful to his art he must nerve himself to resist her seductions, and, if need be, shut his eyes to her attractions—or some of them at least.

For conventional design—and all decorative design is more or less conventional—resolves itself, in many cases, into simplification. In a decorative rendering there is nearly always something left out.

The minute serrations of natural leaves, for example, or their delicate veins, are not to be emulated in wood-carving.

One would select by preference always the simple natural leaves as types—those with smooth edges or broadly marked divisions, those which do not depend upon the veins for their character. A single midrib, or the mere suggestion of it, is often as much as is required in a simple leaf, like the bay for example; or for a three-pointed or five-pointed leaf, just the markings of the main divisions, as in the classic rendering of the ivy.

Look at the best work of any period and you will find that veining is not largely resorted to; and when the veins are given they are mostly shown in relief. The facility with which you can scoop out lines with a V-tool is a temptation which the student can hardly be expected to resist: he is inclined, accordingly, to vex the surface of his leaves with a multiplicity of lines, the omission of which would have added greatly to the breadth and dignity of his work.

I don't say never vein your leaves, but don't do it as a matter of course. Resolve rather not to vein them unless they call for it—in which case you will find that it is only by way of exception that you indulge to any great extent in veining.

A wise plan would be to determine to represent veins only in relief, as in the German Gothic scroll before you—that means making it no longer easy—and the chances are, that any one who set that restriction upon himself would soon break himself of the bad habit of worrying the wood with veining.

Broad surfaces must of course be broken in some way, or they would seem bald and naked. But one may mark the modelling of a leaf, (which is commonly more or less according to the ribs) without insisting upon the ribs themselves. And so also, in the case of a foliated scroll, if it is lines you want, it is far better that they should take the direction of the design, follow the sweep of the scroll, or radiate from the central line, than contradict the leading lines as a bit of naturalism would be likely to do.

You may see what I mean not only in the examples of Indian scroll work on the screen but in almost any example of Renaissance scrollwork—where the veining, such as it is, is in a way modelling also, and helps to explain the form instead of confusing it. Take any so-called acanthus scroll and vein it according to nature—and see how feeble and foolish you have made it look!

The baldness which seems to want veining is often because the carver has not modelled subtly enough, or because he has too carefully smoothed out the record of his cut: that gives of itself, if he will only stop in time, a texture equivalent to (though quite unlike) the natural surface of a leaf.

You will realise more thoroughly what is characteristic wood-carving if you compare, say, the carved Italian cassoni or chests with others decorated in gesso or raised stucco—there are plenty of examples at South Kensington. The designs in gesso have more the character of *repoussé* metal, of beaten work, than of cutting—and the difference is very marked even through the gilding, which always to some extent takes the life out of the carved line.

It really is little short of a sin to cover up beautiful form in gilding—it is like degrading the body of an athlete with gew-gaws and spangles. If a thick coating of preparation is to precede the gilding, as it usually does, all delicacy of carving is worse than thrown away: the carver must be brutal enough to allow for the softening after-process.

A preparation of whitening (or whatever it is) may be, and doubtless is, a very good thing for the gilding, (it is absolutely necessary of course if it has to be burnished) but so far as the carving is concerned, it makes it absolutely dumb, dulls the crisp touch of the chisel, and not only kills the character of the wood but, you may say, buries it.

When you look at a piece of gilded work you can seldom be quite sure whether it is wood or not; you have mostly to infer from the undercutting or its absence, from details which would be too fragile for plaster or too clumsy for wood, that it is one or the other.

I don't want to say anything against gilding—it is exceedingly valuable in decoration—and if the gilded ornament is in relief, it may often be most convenient to carve it in wood. But this, to my mind, comes into quite a different category of work; it is not the art or craft of wood-carving, but wood-carving in the service of some other art or craft—and is ruled then by the laws of that other craft.

The Italian, with all his skill (perhaps because of it) was not prone to care very lovingly for his wood as such. His carving is crisp, free, direct, he is master of his craft and all its tricks, he is a better workman all round than his northern neighbours, but he has no particular preference for wood over any other material, he would just as soon paint, gild, or otherwise disguise the wood—incrust it with ivory, or even wrap it up in velvet or brocade, if it happened to suit his scheme of colour.

In carving which is subject to plastering and gilding, the more highly you finish it the more absolutely your work is thrown away. You want, on the contrary, to exaggerate and over-emphasise its character, that it may not be altogether lost in successive coats of plaster, to say nothing of the glitter of the gold.

It was the glitter of the gold which led the 18th century carvers so far astray from the pursuit of form, and made possible the degradation of the rococo. If you are going to gild carving all over, I don't know that it matters much about anything but broad surfaces, sharp accentuation, and rich effect.

I come now to the consideration of the adaptation of design to the special purposes it has to fulfil, and the space it has to occupy.

I can allude of course only to some of the more important, but much of what I have to say applies (*mutatis mutandis*) to design in general.

First as to *panels*. The panel is the artist's opportunity of doing all he knows. It comes nearer than anything else to a picture, to which the stiles and moulding round it are the frame. I have explained already, in reference to geometric carving, the danger of its design being too insignificant for such a place—there, if anywhere, is the place for a work of art laying claim to intrinsic interest.

It is seldom, however, that the artist is anything like independent of architectural and decorative considerations, even in the panel. He has to consider, here as always, the question of scale. There must be a very definite relation between the scale of the detail throughout the whole scheme of decoration—as also a definite relation of style.

Moreover, unless in the case of a single isolated panel, it has to be taken into account that it is one of a series—which must balance one another; and, in order to maintain such balance, you have to invent what I may call a scaffolding on which to build a sufficient variety of designs.

The larger your panel the more important it is that there should be points of emphasis, and of lesser emphasis in it; and these points of emphasis need to be observed throughout the series, or you lose the rhythm of design.

Before you settle on your *motif* you have therefore to consider whether it is one which allows you to play variations upon it. In the stalls from S. Severino, Naples, you will find a certain similarity in the different panel designs. In the top series there is a sort of swag or festoon in the panel nearest to you—and in the companion panel, though there is no such swag, the ornament falls into lines suggesting a swag. In the two bench ends again you will notice, not only the recurrence of the central cartouche and jewel in each case, but also that the scroll terminates in, or rather springs from, demi-figures. In each case also the scroll is held together at the top by a central figure.

In the choir of S. Pietro, at Perugia, the panels aro not so distinctly on the same lines; but then they are in much slighter relief; they are designed rather with a view to delicate line than to effective mass—so that the detail is not very noticeable until you look for it; and then you find that one character of work is maintained throughout.

In the pierced parapet of the gallery above—where rhythm was of more importance than detail (which would be to some extent lost in that position) design has been economised, and two panels do duty alternately—and with quite adequate effect; but in any more important position to repeat a design is to discount its charm.

In the cabinet front next shown the central heads in the drawer front recur effectively; and the two larger doors are a pleasing break in the monotony of small divisions. They are almost if not quite identical in design. It would have been much better if they had been more varied in detail.

Those two panels, as well as many others I have shown you, are bi-symmetrical—the one half of the design is, that is to say, practically the reverse of the other.

Such symmetry of effect is often invaluable. And though there were no saving of invention therein, one would still very often choose to make the two sides of a panel take the same lines. But it is enough that they should take the same lines, and not be the one an actual repeat of the other. To design one half a panel (or a quarter of it for that matter) trace it, and reverse it, is an expedient only too common in most trades. In some of these (in weaving for example, in stencilling, and so on) there is at least the excuse that it economises labour. But in the case of carving the saving is only in design, and that, as I said in my first lecture, is just the last thing of which the carver should be sparing.

And, just as I said that where two panels are identical in design the interest in it is diminished, so in the case of the two halves of a panel being quite alike.

It is not a bad plan in practice to trace one half of your design (the more roughly the better) and rub it down in reverse, but only in order to get the lines symmetrical and the masses to balance. That much secured, if you are an artist, you proceed instinctively to play variations upon the actual detail: where there is a front view of a flower on one side, you make it a back view on the other, and so on, securing always some variety of incident within the unity of effect at which you aim.

And, mind you, it is no sign of genius to disdain a certain symmetry of design. An artist never sets great store by geometric precision, but he spares no pains to get perfect grace of line and perfect balance of form. The youngster who thinks by carelessness and inaccuracy to show the high artistic spirit inspiring him, is in the way to make a very bad workman.

A *pilaster* may be considered, in one sense, merely a long upright panel. If in its design you adopt the bi-symmetrical plan, you get, more pronouncedly than ever, the effect of a vertical line up the centre of it. You also reduce its apparent width by that means, since the branches of your design can only extend from the centre to the side of the pilaster, instead of right across it.

That would be a great objection to the system but for this important compensation:—the upright direction of the design, and a certain stiffness in it, seem in themselves a very proper acknowledgment of the function of the pilaster, which is to support, in appearance at least, the entablature.

But it becomes more important than ever (since you see them in such a narrow compass) that the two sides should not be identical. In the four pilasters now preserved in the academy at Siena—(which are about as perfect in finish as anything I know of in wood)—there are not only slight variations in the leafage, animals, and so on, but towards the top there is in each case a break in the continuity of the reversed design where a little figure is introduced within the crossing lines of the stem.

You see here also very plainly the attention which the designer has paid to series. The figures, grotesques, vases, and so on, all range perfectly in horizontal order. In fact, having designed one pilaster, the carver has marked off the main divisions on the others, and designed them within those lines.

In the pilasters next shown the central upright line is less emphatic, and the shapes on each side of it are rather balanced than reversed; but even the figures which break the line have a distinctly upright tendency. These pilasters being, as you see, much longer than the others, it was not necessary to emphasise their length.

It is sometimes argued that decoration should always emphasise construction. That depends. If a pilaster is too short you want to emphasise its length, if it is too long you often want to break it—as you may do by the introduction of medallions or distinct horizontal divisions; what you really have to do in decoration is not necessarily to emphasise the constructed form but to acknowledge it. That is enough.

In the pilasters from Verona (which I show you once again) there is absolutely no reversing of the design at all—the wave lines in the two side divisions are not even opposed as one might have expected them to be. The fact is that in such very low relief the upright forms of the pilasters would take care of themselves—and here there are no less than five well-marked uprights, which assert themselves very emphatically.

I don't say therefore that a scroll or waved design may not be useful in pilaster decoration, but it is not obviously adapted to it, and wants very discreet handling. I think also that in a pilaster the relief should be moderate. There is something unsatisfactory when the pilaster is so to speak cut away, and you only see ornament in its place.

Least of all is it allowable to make any part of a pilaster project beyond the margin. The ornament must be carved out of the solid, and look as if it were.

With regard to *columns*—you may band or ring them if you want to shorten them, flute them if you want to reduce their thickness. Another way in which to acknowledge the roundness of the column is by lines twisting round it—and it is a way especially adapted to the decoration of the little pillars which occur in cabinet work. What might be trivial in architecture, is there only pleasantly fanciful. The actual twisting of the column itself, as though it were a sugarstick, is but a poor expedient, contradicting as it does the very idea of a possible support.

Concerning *capitals*—there is no use in saying much: the carver is mostly instructed to work to pattern, Corinthian, composite, or whatever it may be.

For my part, though I am no bigoted believer in Gothic sufficiency, I do like to see the bell of the cap; and I would rather see the carving take the form of the bell than disguise or even clothe it.

There are two time-honoured ways of decorating a *frieze*.

(1) With a continuous scroll.

(2) With cross lines dividing it up into panels more or less—as for example the triglyphs in the Doric frieze of which there is a Renaissance rendering in the photograph on the screen from S. Maria in Organo at Verona.

In the case of the scroll the idea is of course to emphasise the horizontal direction of the frieze, in the case of the cross-lines the idea is to interrupt too marked a tendency in that direction.

Either plan is equally useful on occasion. A more generally available plan is perhaps a combination in which the scroll is interrupted, or perhaps not continuous at all, a repeated pattern, in fact, marking at short intervals the upright line—only much less emphatically than in the case of the triglyphs. There is an instance of that also on the screen.

A similar result is produced by the introduction of big rosettes, masks, or other important objects at intervals in the frieze: they also connect the members framing it, and steady the design.

What you have to ask yourself is—should the design, in any given case, be continuous or stopped, and, if stopped, how?

In the case of *mouldings* a very broad moulding indeed, partaking somewhat of the nature of a frieze, may be treated more or less in the same way, especially if it be very flat in section. For the rest the tendency of mouldings is to be too liney.

This is corrected by carving in the cross direction. They may be crossed in two ways—

(1) Straight across, or

(2) According to their contour.

That is to say you might take a plumb-line and mark off the divisions. Or you might take the section of the moulding (the line you would use if the moulding were "returned on itself") and repeat that at intervals, reversing it or not. The billet or the reel pattern is an instance of the first method. The bead or the egg and tongue of the last.

The old mouldings are always carved more or less on these principles: it is only the house-painter and decorator who ever yet thought of emphasising the parallelism of mouldings by "pricking them out" in colours—when already they pick themselves out if anything too much.

The old patterns, too, are in the main good, so good that, I will not say they must be copied, but you must work on their lines. The fact is that within the limits of a moulding an inch wide, or two, or three at the most, there is no great choice of lines on which to work; the best have long since been found out, and the fittest have survived.

A very essential thing in carving mouldings is to preserve their contour. This may be done by keeping the carving so very low in relief as merely to soften the contours, as in the table on the screen, and in the cabinet which follows it.

The other way is by leaving so large a part of the actual surface of the moulding intact, that the carving resolves itself into certain incisions, the surface forming of course the design, the incisions so to speak outlining it; the pattern in that case being so full that there is practically no background to be grounded-out.

In furniture at all events I would insist upon all carved mouldings answering to one test—that you should be able to pass your hand along them with some degree of comfort.

To sum up on this subject, the object of mouldings being to mark by parallel lines of light and shade some architectural feature, it is clearly irrational so to break them up with carving that the cross shadows disturb that parallelism which is their very *raison d'être*.

In the case not only of panels and pilasters but of compartments of all kinds, it is most distinctly desirable that the design should be carefully adapted to the place it occupies. The square panels of those two ceiling coffers for example fulfil that condition of design—not so the marginal strips. These appear to have been carved by the yard and cut to the lengths determined by the framing. That is, to me, an unpardonable fault in these otherwise beautiful designs: it tempts me to wonder whether it is wood-carving at all, whether it is not stucco or something cast on a mould, where the design could not be modified to fit the various spaces. This is Italian work, but where it occurs I don't know. The photographs were lent to me by my friend Mr. Thos. Armstrong.

The circumstances controlling design are not always entirely under the control of the designer. On the contrary he is ordinarily very much the victim of circumstances. Given a Gothic rood-screen or a Renaissance doorway to carve, and he is bound to keep within measurable distance of Gothic or Renaissance precedent, as the case may be.

Even in work less strictly dependent upon architecture there is nearly always something (if only in the dimensions of the thing to be carved, or in its proportions) which must perforce influence, if not actually determine, the character of design befitting the circumstances.

Broadly speaking, you want in the minor mouldings simplicity, in the more important panels interest, in the strictly architectural features severity, in the subsidiary spaces subordination—and so on.

A panel may be as I said, under certain circumstances almost a picture, or rather a bas-relief—a work of art in which the sculptor is bound only by those unwritten laws which the true artist obeys by instinct.

But such cases are altogether exceptional. In the great majority of instances even a central panel has to be considered in relation to the *ensemble*—very likely in relation to other panels—and to the enrichment of the work generally. And there must of course be no incongruity between the carving of panels, frieze, mouldings, and the rest. The consideration of scale, again, is most important. Not that the natural scale of leaves, flowers, fruits, animals, &c., is always to be observed—on the contrary; but everything must be of a piece: one must never be allowed to feel that this is too small or that too large for the rest.

And the same thing applies of course to style. The style, whether your own or borrowed, whether founded on nature or on old work, however eclectic in character—must be one. Any transition from severe to florid, or from conventional to natural, must be so gradual that it seems to come by growth. When this appears too natural for that, or that too conventional for the other, it means that the designer was not equal to the control of his resources, and so failed.

The question has sometimes been put to me by students—how ought one to set about designing; should we adopt some historic style and follow that, or should we follow nature?

The answer to that is very simple:—neither.

Take nature or an historic style, which you please, and then depart from it. Neither in nature nor in any historic style will you find a model, but only a starting point—a point of departure.

But this departure must be made with discretion—it must be no rash flight into the unknown—and in order to depart at the right moment, one must be thoroughly informed; one must be thoroughly acquainted, that is to say, with what is in nature and with what has been done in art.

There is a so-called freedom which is only license. I am not advocating that, nor yet the reliance of the student upon his unaided ignorance: the one thing fatal to him is cocksureness, the belief that he knows better than any one can teach him. There is a story of a potter who rebuked his apprentices by saying:—"Yes, yes, young folks thinks old folks is fools, but old folks *knows* young folks is." Now the best plan is not to think other folk fools nor ourselves geniuses, but to use our brains and think for ourselves. And to think for ourselves does not imply that we should pay no heed to what has been thought by others before, as some of them at least were better men than we are. On the contrary, we have to begin by assimilating all they knew before we can give off anything to the purpose on our own account. Still that does not mean to say that we have any occasion to limit our aims to the reproduction of old work. Most old patterns have to be taken *cum grano salis*, and sometimes that salt needs to be a pretty big lump.

There are plenty of things we admire in old work which in any modern reproduction would be far from admirable. One must make studies from old work, copies more or less, but so soon as you begin to design something more is wanted. A mere shuffiing of old details, and putting them together in slightly different order, is not to be dignified by the name of design.

It is not in order to find ready-made detail that one studies old work but to see how difficulties were solved, what methods were adopted, what expedients resorted to, and wherein these methods and expedients succeeded, and wherein they failed. Follow tradition if you will, or if you must, but don't follow traditional forms—there is no tradition for that.

Something about style you will have to learn, then; and I daresay most of you have learnt something about it (if not a great deal) merely in the way of business. So long as fashion reigns (and it is a mystery to me that, with all our schemes for the advancement of art no one has ventured to suggest the removal of the main obstruction—fashion), so long as fashion reigns, the folly of the hour dictates to you that you shall work in this style or that, if you want to earn a living.

Well, so long as you must, you must.

But I can't help believing that any workman with the possibility of an artist in him must have some natural leaning towards one kind of work or another, and I am certain that uuless he would lose those inward promptings and sink into a mere mechanic he must cultivate them. And here I can give him, out of personal experience, a word of encouragement.

When he knows something about the styles in which he is called upon to work, it will not be so very difficult to him, even in a style with which he has not much sympathy, to lean somewhat in the direction of his own choice.

Styles, that is to say, are not the cut-and-dried things we begin by thinking them. It answers the purposes of convenience to separate them one from the other, and to give them names according to the kings who patronised them (or perhaps didn't). But in reality they merge one into the other, overlap, and interlace—so much so that we find experts of some authority perpetually at variance as to the date of this or that example.

We find besides that there were always men lacking in initiation, men without originality, and bat-blind to whatever was not out of date, who worked on complacently on the old old lines, years, and tens of years, behind the more wideawake part of the world.

An expert in style has therefore pretty well to devote his life to it, and patrons and employers are accordingly not experts in any thorough sense; and if you know something about what you are doing (it is not difficult to know more than they do) you will easily be able to get a good deal of your own way; and you may safely twist a style (*I think you ought to twist it*) somewhat in the direction of yourself.

I know that, if you are not content to be a mere copyist, a sort of licensed forger, you are sure to be pulled up short by some stickler for precedent in authority over you. But it will not be difficult in any style to find details more in accordance with your own bias than the ordinary stock forms. And if, when these are objected to as contrary to precedent you can quote chapter and verse for them, the stylist (who is naturally a timid creature) will begin to be afraid of you, if not to believe in you, and will let you go pretty much your own way. You will be free then to take liberties on your own account—really to design, instead of only pretending to—so long as you only arrive at harmonious results.

That is the whole gist of the matter—that the result be harmonious. Whatever style you start from, or assuming that you have to restore or decorate a work of some pronounced period, all that you are bound artistically to do is to make it one in effect. If, on examination, it becomes apparent that the new work is not, and cannot be, old—that it is new, yours, has the stamp of the present day and of the workmen's individuality, why so much the better. And, indeed, so much the more is it really like old work, which was always unaffectedly of its own period, and always the direct expression of the man who did it.

So far from the styles being anything like cut and dried—pattern books to copy from—much of the most interesting work is transitional in style, halfway between one Gothic period and another for example, or between Gothic and Renaissance, like our own Elizabethan, or the French François 1er.

The later German Gothic work becomes also more interesting when it begins to be tinged with Italian feeling. In the panel from the choir stalls at Ulm you cannot but see the influence of the Renaissance scroll—Gothic and German though it be.

The German, said a French writer on art, remains to the end an impenitent Goth, on whom the saving grace of the Renaissance was for the most part lost. But there are traces of it in his latest Gothic, and they give to it a piquancy lacking in the pure style.

In French transition work the Renaissance influence predominates. You see it in the details on the screen from S. Denis. The style of François 1er may be described as Renaissance with a lingering trace of Gothic influence. The forms in fact are almost purely Italian, intentionally as Italian as the Frenchman could make them; but the foundation of the design, the constructional lines, are still more or less Gothic—unintentionally so, no doubt. The courtly grace is as yet only on the surface; the hand we might blindly take to be the hand of an Italian, but the voice is unmistakeable; it is the voice of a Goth.

The panels from Oudenarde are rather later I should say—and more distinctly Renaissance, but they are still tinged with the Mediæval influence: you can see more plainly than in Italian work how the artist blocked out his forms, and the severer and squarer lines on which he planned his design. I speak of the Oudenarde work as François 1er because it is distinctly French not Flemish in character.

I will show you an example of distinctly Flemish work—which is, the chimney-piece of the Hotel de Ville at Bruges. It is pretty clear that some of that carving is applied—in fact it is so frankly "put together" that it anticipates criticism in that respect. Of the strength of the design, the richness of the effect, and the remarkable execution of the carving, there is no question. It may be too florid for some tastes, but in its way it is unsurpassed.

Our Elizabethan and Jacobean styles had more affinity with Flemish than with French work. You see that in the strap-work and cartouches, and in the rather heavy architectural lines.

I showed you two Elizabethan interiors last week. You have now on the screen some details from Benthall-hall, in Shropshire—excellent examples of a kind of English work which, if not remarkably interesting, is rich, and typical of its period.

The Middle Temple hall is probably the most magnificent specimen of Elizabethan wood-carving in London; but it is more distinctly in the Renaissance manner than characteristically Elizabethan. It may very possibly have been executed by Englishmen, but that does not betray itself by any peculiarly British accent, as it does in the less pretending work for example at Gray's-inn which I showed you last week. It is quite possible the design is due to one of the distinguished foreigners upon whom the Tudors were accustomed to rely for their art.

The Renaissance indeed is the style in which we find the most finished workmanship and the most delicate design in wood-carving—not necessarily the most vigorous or the most suggestive, but the most beautiful certainly. I have shown examples enough to bear me out in that.

It was in the 16th century that the art of carving (like so many others) culminated—thenceforward, if it did not go persistently down hill, it erred always more or less in the way it should not go.

The Renaissance proper begins in France with the school of Fontainebleau, 1530, but it is only under Henri II. that it spreads over France. By that time the new manner is established with all its *impedimenta*, masks, grotesques and arabesques, cartouches, swags, cariatides and the rest (as you see in the works of Jean Goujon), growing only more redundant under Charles IX. and Henri III.—witness the designs of Du Cerceau. I take it that I am speaking to those who have a fair notion of what Renaissance design is. It is all the easier to have some such notion because of the continual recurrence of its characteristic features—swags, cartouches, grotesques and so on—which were used too much as convenient properties.

The perpetual recurrence of these features becomes monotonous at last—even where they are in themselves beautiful, which is not by any means always the case. I am not going to defend the ugly forms, or their use as the designer's stock-in-trade; but I would like to remind you once more that many an ugly feature fulfilled an important function in design.

The problem before you is how to get the breadth and richness of effect others have arrived at by means of which you cannot approve.

You must not understand me to condemn the use of the grotesque, or indeed of any of the properties of the Renaissance. It is of their use as properties, that I disapprove and of the reproduction of stock forms, as by recipe. With regard to the grotesque in particular, we cannot well afford to dispense with it—and I don't see why we should.

Nature being so far as we are concerned a secondary consideration, we are perfectly justified in making it conform to our artistic wants. Design is to be judged by rules of art not of Nature. If it suits you to make your beasts break out into foliage, or your foliage to blossom into beasts, you are perfectly free to do it, as you are to combine the characteristics of two or three different plants in your foliated ornament—if you can. There is one guiding rule: you may do what you can make seem right.

In so far it is your affair. It depends upon your individual capacity, your power of combining and harmonising what in other hands might appear to be incongruous details. Your success in this will depend, however, in a degree upon the judgment of your critic, whose sympathies may be so narrow as to leave absolutely no scope for your fancy, or so broad as to condone the wildest extravagance of invention.

There is thus a certain possibility, always, of your being judged either too severely or too leniently, as the case may be. But, on the whole, you will find that those who really know—and it is only their opinion which is worth a thought—you will find that those who know will have no desire to restrain you from doing what you can do well. Should any license of yours be generally resented, you may conclude that it is because you are not equal to the task you undertook.

When we say that such and such ways are right, such and such practices well-advised, or when we condemn recourse to certain other methods, it is not with any idea of dogmatising, or pretending to determine just how far one may go and no further. All that a reasonable preacher wants to impress upon you is, that you may go thus far with safety, and that beyond that point there is very considerable danger of failure and disappointment.

For the masters there are no ready-made rules. Genius (once it has come to maturity) is a law to itself, and a sufficient one. Rules of art are all, so to speak, "students' size." Accomplished artists make their own—to the measure of their genius.

In teaching and preaching one takes it for granted one is talking to learners. Them I should advise to beware of using stock properties, to have some reason in their maddest flights, to be most careful of congruity, and, when objection is taken to their work, to be more ready to think that the fault is theirs, than in the critic.

Of distinctly Renaissance work England has not very much to boast. The Elizabethan was a sturdy hybrid style. But by the time the Renaissance was established in England it was too late; it was already on the decline.

Grinling Gibbons worked at a period when restraint was no longer in fashion; if he had lived a century or two earlier we should have had something worth boasting of.

The aim in that canopy design of his is altogether misdirected. It strives in the picturesque direction, not in the sculpturesque, and though it may succeed in its aim, it fails as carving—from the point of view of design, that is. I have no word to say against the work; but only to lament its misdirection. The festoons and the flowers and the naturalistic palms (which are not a bit like nature, by the way) are not worth discussion as design: the utmost one could say in praise of the design is, that the mouldings are not amiss, and that the scroll-work immediately over the arch is good.

So is the scroll work next shown. It is late in style—it could not be otherwise; but it is free in its growth, graceful in its lines, and effective as enrichment. The cutting is of course beautiful: one can only wish that the master English carver had done more such decorative work, and not wasted his energies on merely picturesque productions.

England of course is not alone in her departure from the right path. In the Netherlands, where there are some marvels of woodcarving, there are also some marvels of bad taste—the altar of St. Jacques at Antwerp, for example, which is attributed to Rubens. If I were a carver I should only be too glad to let a painter have the credit of it.

At Louvain the pulpit is more like a grotto than a construction of wood; and that at Malines is for all the world like a monster bird's-nest.

In France again the later styles are not so many models of perfection. It was suggested to me that carvers would find it of great practical use if I could give them some simple explanation of the characteristics of the later French styles, just now so much in vogue.

That hardly comes within the scope of these lectures—and besides having little sympathy with those styles, and a strong objection to their introduction among us (an introduction altogether in the interests of trade, and not at all of art, or even of manufacture) I am not precisely the person to speak feelingly of their virtues. Were the styles themselves less vicious than I take them be, I should still see only the absurdity of any affectation of 18th century French art in England in the 19th. Fancy 19th-century-English-18th-century-French! what a mixture! Mongrel is too good a word for it.

My advice then to the craftsman is to go only so far in the direction of the later French styles as he is compelled. Sometimes he is compelled I know—at all events his bread is sometimes buttered on that side; and he cannot always afford to decline to work in a style which does not appeal to him. I have already explained how, even then, he may to some extent use his own faculty of selection, and possibly his invention; and he may console himself by the throught that there is something to be learnt from any style, something which very likely his leanings in another direction have prevented his knowing.

I am assuming that he has leanings of his own, and does want to go that way. If he is anxious only as to the amount of butter on his bread he is less craftsman than tradesman—let him study the market—that is his bible.

If you must then, in obedience to demand, work in some poor style, you must; but do the best you can in it. Try and make your design good even though it be only just "Louis XVI." enough or "Empire" enough to swear by.

As in the case of the earlier styles so in the later there is no hard and fast line of demarcation between them. The divisions are indeed more or less arbitrary. The Rococo which is characteristic of the period of Louis XV. existed already in the later days of Louis XIV; and the reaction in favour of classic refinement and severity which marks the reign of Louis XVI. began as early as 1750, and work of that character was done concurrently with the Rocaille of Louis XV.

For purposes of distinction one may call the work of the latter half of the 17th century Louis XIV; that of the first half of the 18th century Louis XV.; that of the second half of the 18th century Louis XVI.

There are fairly typical examples of the three periods on the screen.

But for my part I don't quite see what Louis *le grand*, or Louis *le bon*, or any Louis, had to do with it. As kings they may have helped or hurt it by their patronage. But it is is the artists of their reigns who concern us—and it would be much more reasonable to classify art according to them, and not according to kings at all.

Thus instead of Louis XIV. I would say the rich, sumptuous, over-magnificent art Le Pautre, Le Brun, Berain, Boulle and Gouthière; instead of Louis XV. I would say the frivolities and pretty affectations of Watteau and Boucher, and the downright license of Meissonnier; instead of Louis XVI. I would say the refined and delicate, if not very serious, work of Salembier and Lalonde.

What characterised the art of a period is plainly the character of the artist. If you want, then, to acquire readily some knowledge of a period, study the works of its greatest master—if you want to work in the manner of a period take some one artist as your tyye. You will not then be distracted by what seems like contradictory evidence.

There are excellent books published illustrating the later French periods. Look through them in the library at South Kensington. Choose in each period the man whose work appeals most to you, study him, get photographs of his work, make drawings of it, and found yourself so to speak upon him—and remember that if there have been some bad styles there have been good artists in most periods, and from such there is always something to learn.

Apart from the necessity of adapting yourself to commercial conditions—some knowledge of style is of course an essential part of your education in design—and that implies some knowledge of history too.

When you realise Louis XIV.—the *grand monarque*, who took it quite seriously that his courtiers should compare him to the sun, you begin to understand the ultra-magnificence of the art with which he surrounded himself—nothing could be too splendid. The licentiousness of the Regency and the degradation of the Court of Louis XV., and the ascendency of Madame Du Barri—fully explain the caprice and affectation of early 18th century French art. And when we understand the interest awakened in the latter part of the last century by the discoveries at Herculaneum and Pompeii, we begin to understand also the return to something like severity of line and elegance of proportion, which marked the period of Louis XVI.

So with earlier and more dignified periods. Certain features of Flemish work cease to be a mystery when you appreciate the effect of the Spanish occupation of the Netherlands. Some peculiarities of the Venetian manner are explained by the direct communication of the city with the East. Dutch William helps to explain our own Queen Anne.

The moral is that intelligently to follow even a simple craft a man must educate himself.

In concluding my lectures I should like once more to express my thanks to Mr. Armstrong, Mr. Bliss Saunders, Mr. Aumonier, and especially Miss Rowe for the use of photographs and to Miss Rowe again, Mr. Ross, Mr. Stephen Webb, and especially Mr. Aumonier for their hints. They very kindly allowed me to cross-examine them on technical points on which their opinion was better worth having than mine—much to my advantage—and I trust to yours.

Miscellaneous.

THE GIFFARD GUN.

The *Times* has given an account of a new gun, the propulsive agent in which is carbonic acid gas, compressed to a liquid condition, and capable of giving a pressure of 500 lbs. per square inch. The liquefied gas is contained in a metallic tubular reservoir about 9 in. long, which is fixed under, and in a line with, the barrel of the gun, and which is conveniently grasped by the left hand in firing. Although containing an immense store of power, there does not appear to be any danger in a weapon thus equipped. In the first place, the reservoir is made of Siemens-Martin steel of the highest quality, so that a burst is considered hardly possible; and, in the second, should a flaw in the metal lead to a fracture, the gas would simply escape much in the same way that it does on the opening of a bottle of soda water. Then, the quality of the metal used for the gas receiver is such that it will stand rough usage without liability to fracture. It may be, and, indeed, has been, knocked greatly out shape when full of gas without any prejudicial result arising, the gas having been afterwards used for discharging projectiles from the gun. The bullet is dropped into a small aperture at the rear end of the barrel, and by moving a small lever it is deposited in the breech chamber of the gun. The hammer of the gun is then placed at full cock and the trigger pulled. By the fall of the hammer a pin is struck which opens a valve at the rear of the liquefied gas reservoir, and permits the instantaneous escape of a sufficient volume of gas for one discharge. The bullet is thus ejected with a force proportionate to the impelling power of the charge, which can be increased or decreased at pleasure by a simple screw arrangement. In other words, the propelling power is completely under control, although, of course, this in practice is not left to the arbitrary will of the ordinary user, but will be fixed and definite, according to the character of the gun in which it is employed. The discharge of the gun is unaccompanied by any report, nor is there the least recoil or kick. On pulling the trigger there is a slight hiss or puff, followed by the noise of the impact of the bullet upon the iron target. The reservoir is very light, and, when charged with liquefied carbonic acid gas, is capable, according to the size and calibre of the gun, of discharging from 100 to 500 consecutive shots at a stated cost of less than one penny. It is stated that there is no fear of any part of the gun or its mechanism becoming oxidised by the gas, and it is hardly necessary to add that there is neither smoke nor smell from the propellant. There is also no deterioration of the liquefied gas from storage or keeping. With regard to the rifle itself, with the exception of the tubular reservoir carried under the barrel, there is no material difference in appearance between the Giffard gun and an ordinary weapon of similar character.

Notes on Books.

GAS AND PETROLEUM ENGINES. By William Robinson. London: E. and F. N. Spon. 1890.

This treatise, the author of which was for some time on the teaching staff of the City and Guilds' College at Finsbury, gives a very full account of the principles which guide the construction of the modern gas-engine, and of the most important recent forms of the gas-engine. The first portion of the work shows the action of the engine as exemplified in the "Otto" gas-engine. Then comes a chapter on the use of petroleum, including its use simply as a fuel. Following this, in Chapter V., we have the historical portion of the subject. Next, an account of the principal types of engine, and after this the remainder of the book deals with the practical details of the engine, and the theoretical principles involved in its construction and use. In the final chapter, on the testing of gas-engines, full use is made of the Report of the Society on this subject.

GEOLOGY OF LONDON AND PART OF THE THAMES VALLEY. By W. Whitaker, B.A., F.R.S., F.G.S., of H.M. Geological Survey. London. Two volumes.

This memoir of the Geological Survey contains much information of practical value, both directly and indirectly; as well as a larger amount that is of interest to paleontologists and those who study the origin of scenery, the antiquity of man, or the past physical changes which have taken place within the area that is now the S.E. of England. Rich in bibliographical references, it gives a concise history of the geological work and speculation that has been devoted to the district described, from the time when, at the beginning of the century, it began to arouse some attention. And the history has involved many allusions to collateral work in other parts, to broad speculations, and to the discussion of many fundamental geological principles, such as the relative value of paleontological and stratigraphical facts as evidence. The work is encyclopedic in its scope, and the writer, in addition to summarising or referring to all printed information, has largely availed himself of the MS. note-books of his colleagues on the Survey, and given the results of his own 33 years survey experiences.

Among the portions of the work of direct practical value that which, from its fulness, ranks first is the extensive collection of details of sections obtained in digging for foundations, in making dock and railway excavations, in well sinking, and from deep borings. These occupy 239 pages of vol. ii. The details are so numerous* that (except for very deep borings) engineers, architects, and contractors, who may have to plan any future works could thus tell, with considerable exactness beforehand, what they would come upon in excavations in any particular locality. Further, as regards deep boring for water, it is pointed out that boring to the lower green sand, which at one time was thought capable of yielding large supplies, cannot now be expected to give results commensurate with outlay.

A very important practical section is that on the water yielding capabilities of the chalk, in which are given generalisations applicable to other parts of the country; and it will be seen that these considerations are new. It has for long been customary to base calculations on the water-yielding capabilities of the chalk upon the rainfall, but the writer shows this is a fallacious method, and has led to its being over-estimated, for a large proportion of the areas mapped as chalk on the "solid geology maps" of the Survey are covered by "drift beds," and these, though thin, contain clays which are impermeable to water. The mapping of the drifts has been for some time in progress, and as some maps are already completed, they are taken as data for showing the importance of distinguishing bare chalk from drift-covered chalk. This can be seen by tabulating some of the results given.

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* There is in the office of the Survey in Jermyn-street a map on which the sites of the borings are marked. It may be consulted on application.

Let *a* stand for chalk, bare; let *b* stand for chalk covered, but with permeable material; let *c* stand for chalk covered with mixed material, sands and clays, so that water is only partially stopped; let *d* stand for chalk covered with impermeable clays. On three of the finished maps the areas in square miles of the divisions are as follows:—

	a and b.	*c.*	*d.*
Sheet 1 (S.W.) ..	34 ..	58 ..	104
,, 1 (S.E.) ..	12 ..	20 ..	133
,, 7	208 ..	176 ..	422

from which it will at a glance be seen how in each case the figures under *d* are larger than *a*, *b*, and *c* together. Roughly, considerably more than half the chalk is prevented by impermeable beds from receiving the rainfall. There is also another important practical point referred to. All water-bearing beds, it is shown, may be divided into those which are loose, in which water percolates between the particles; or compact, in which it passes along planes of division. Chalk is peculiar in this, that while most water passes by the divisions, it in a less degree passes between the particles, as may be observed in the phenomenon popularly known as "weeping." To get a supply of water the divisional planes should be cut through, and the more cut the greater will be the yield of water. Wide digging, it is urged, is therefore better than mere boring, and adits cut in different directions much increase the supply.

Other practical information is embraced in chapter xxviii., "Economic Geology." This includes an account of the materials used in buildings that are found in the district described; the various kinds of hard chalk, flints, and grey-weather sandstones, of which a great part of Windsor Castle is built. The materials for brickmaking, with the localities of their occurrence, are also given, and also for lime, cement, and whitening. London's supply of lime is stated to be almost entirely from the chalk, and there is scope for a greater attention to a cheap lime supply for mortar. Road metal, foundry sand, and material for application to various soils for agriculture also receive notice.

Though not of the same direct practical value, yet now recognised to be very important, are the subjects included in the section which deals with the theoretical question—what are the beds that lie under the London district, and what is the probability of coal being reached in the neighbourhood? The question of coal being found somewhere in S.E. England in quantities that it would pay to work was the subject of a paper by Mr. Whittaker, at one of the Ordinary Meetings of the Society, which was printed in the *Journal*, No. 1,953. The two sections given on p. 546 show how the earlier speculations respecting the beds far below London have been modified by knowledge gained from deep borings. These borings, made in search of water, have led to the question of the possibility of finding workable coal. The chapter "Underground plain of older rocks," gives in pp. 10 to 50 (with full references and many quotations) a succinct history of the stages in working out the problem of what beds lie deep below the Thames.

General Notes.

Railways.—A member writes respecting the Table of railway mileage (see *ante*, p. 804). "It appears by the statement that there are in Europe 132,289 miles of railways, and as it requires, on an average, one locomotive engine to a mile of railway, there must be about 132,289 locomotive engines, which at 20 horse-power average, will give 2,645,780, or about two million horse-power in use. But 20-horse each locomotive is too low an average of power. Coaches, in the old coaching days, required one horse to each mile of road run over."

Precious Stones in Australia.—Under the generic name of *Corundum* are included the most valuable gems known to commerce next to the diamond. The sapphire, which is the most common of these gems, is found in all the colonies. Oriental emeralds are found in New South Wales and in Gippsland, in Victoria. The yellow corundum, or Oriental topaz, has been found in New South Wales. Oriental amethysts also have been found in that colony, and the red corundum, or ruby, the most valuable of all these gems, has been found in Queensland, as well as in New South Wales. According to an authority on the subject of gem stones, rubies, Oriental amethysts, emeralds, and topaz have been chiefly obtained from alluvial deposits, but have rarely been met with in a matrix from which it would pay to extract them. Chrysoberyls have been found in New South Wales and Victoria, white topaz in all the colonies, and yellow topaz in Tasmania. Zircon, tourmaline, garnet, and other gem stones of little commercial value are found in all the colonies. In South Australia some very fine specimens of garnet were found, which caused some excitement at the time, as the gems were mistaken for rubies. The stones were submitted to the examination of experts, whose reports disclosed the true nature of the gems, and dispelled the hopes of those who were interested in the supposed ruby mines of South Australia.

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CANTOR LECTURES.

STEREOTYPING.

By Thomas Bolas, F.C.S., F.I.C.

Lecture I.—Delivered February 17th, 1890.

Historical Notes and General Considerations.

The notion of casting from the assemblage of types, known to the printer as his "forme," seems to be nearly as old as the art of printing from movable types, a thing easily understood when one remembers that the art of fine casting in copper alloys was well understood four centuries ago, and the advantage of a solid page, not subject to fresh errors at the hands of every careless workman, must have been very obvious to those early printers, who tried so hard to eliminate errors of the Press. Indeed, as regards the early history of stereotyping (in a copper alloy, such as brass or bronze) we may go back to the work of a Chinese stereotyper, who according to Skeen* laboured very successfully about the year 1041.

The incentive to stereotyping in the early days does not appear to have been so much the multiplication of "formes," for the rapid production of copies, or the saving of type—for the old printers had very large founts—but the notion that mainly set the matter going seems to have been the desire to secure that accuracy of all copies which can never be depended upon when movable types are used for printing.

Accordingly we find that one of the first considerable use of brass stereotype plates was for tabular matter, Gabriel Valleyre, a printer of Paris, having produced numerous calendar plates about the year 1700, the brass being cast in clay or loam moulds. Valleyre's plates were small—about such size as one would use for foolscap octavo pages—and the sharpness of the letters was very much inferior to that of the type pages printed alongside. Still the brass plates answered their purpose to a certain extent, but the want of sharpness of such casts, and the difficulty of making large plates, were sources of trouble to a clergyman of Leyden, Jean Muller, who with his son William, was endeavouring about this time to produce stereotype editions of the Scriptures (1700-1711). After numerous experiments in brass casting, this gentleman adopted the plan of producing solid pages, first by cementing the types together, and afterwards by melting the types together at the feet; this latter process being a very easy one if the "forme" is locked up so as to be thoroughly framed with the wooden furniture, and is placed on an iron surface which can be gradually heated to something short of redness. Muller was an enthusiast in his work, and he produced in this way a Syriac New Testament, a Greek Testament, and a Dutch folio Bible. This latter work was reprinted from his blocks as late as 1791 by Elwe, of Amsterdam, and some of his solid pages are in existence at the present time.*

The process of casting plates of type metal in plaster moulds appears to have originated with a goldsmith and money-lender of Edinburgh, William Ged (1725), who was moved to experiment by a conversation with a printer, who told him a fortune would be the result of success in casting from the "forme." In a few days Ged managed to produce excellent casts, and set about looking out for the fortune which was to be the result. Ged and his sons seem to have spent most of their efforts, during a period of about half a century, in getting fresh partners, and in quarrelling over financial matters, with the result that they got no profit out of the transactions; but during this time many persons got hints as to their method of working, and the plaster process was experimented with in various parts of Great Britain. During this period (1740) Michel Functer, a printer, of Erfurth, stereotyped by the plaster process. He made a paste by mixing—

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* William Skeen, "Early Typography." Colombo (Ceylon), 1872.

* With a view of ensuring accuracy, Firmin Didot, in 1794, issued logarithmic tables in what he termed "stereotype;" but in this case the types were merely cemented together in order that there might be no risk of introducing errors in working from them or in handling them. More recently, Charles Babbage (1827) took advantage of stereotyping to ensure greater certainty in tabular work, his tables of logarithms having been stereotyped before the final proofs were read, and the corrections were made by cutting out the false figures and soldering in the necessary types, a proceeding which eliminated the old difficulty that, in making corrections, fresh errors were so often introduced. Corrections in these plates have been made from time to time, and an edition was printed last year by Messrs. Spon and Co.

Plaster of paris	5 parts
Crushed brick	2 ,,
Asbestos	1 ,,
Water enough to make a paste	

This was spread on a slab, and the type "forme" was pressed into it, and when the mould thus obtained was dry, the type metal was poured into it. Functer published details of his method in the form of a pamphlet, but Ged—who seems to have worked in a very similar way, *i.e.*, by forcing the face of the forme against a soft bed of plaster, and not by pouring the mixed plaster over the forme—endeavoured to keep his process secret.

Functer also described methods of casting type metal in sand moulds, the sand being bonded by linen or woollen fibres, and by the use of beer for mixing. To Functer belongs the credit of giving the plaster process of stereotyping openly to the world, and there is no record of the time when he commenced his experiments, or whether he knew of Ged's work.

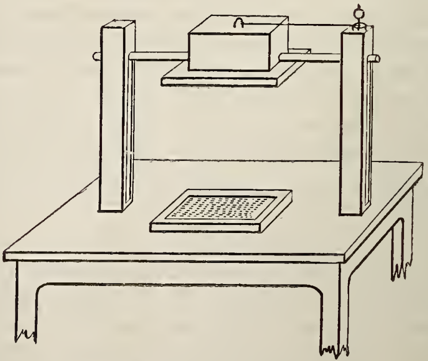
The introduction of D'Arcet's fusible alloy, 1773—an alloy composed of bismuth, 8 parts; lead, 5 parts; and tin, 3 parts, and which melts below the heat of boiling water—was looked upon in Paris as likely to be of great service in stereotyping, but little was done with it beyond some experimental work.

About this time stereotyping was an established process, and was in regular use in several of the larger printing offices, especially on the Continent, and we find several persons publishing working details, notably Joseph Hoffman, who made moulds of plaster and clay, tempered with gelatine, gum, or starch (1783), while Andrew Foulis, of Glasgow (1784), was casting plates regularly, with the co-operation of Alexander Tilloch, of the same place. The stereotype books of Foulis are well known, and need no mention here.

Stereotyping methods were extensively employed in reproducing the small notes or *assignats* of the Revolution period in France, it having been found impossible to prevent forgery while the designs on the authorised notes of the same denomination varied, and when engraved by hand they were found to vary in spite of every care. It was not, however, till 1797 that Gatteaux, who had charge of the printing of the *assignats*, got the stereotyping arrangements of the national printing office in good working order, and the method he adopted was one perfected by the celebrated printer, Firmin Didot, although originated some few years previously by Joseph Carez, a printer of Toul.

According to this method, to which the name "Polytype" was frequently applied, the page of type, or the original to be copied, is slightly oiled, and fixed face downwards on a block of wood, supported, at some little distance, over a paper or cardboard tray, into which melted type-metal has been poured. Just as the type-metal begins to show distinct signs of solidification, the block carrying the page of type is allowed to fall on the soft metal, and on separating the two a reverse, or mould is obtained. This reverse, or mould, being now fixed upon the lower face of the drop-block, is allowed in its turn to fall on the surface of type-metal contained in a paper tray, this metal being at the point of solidification as before. The paper tray is of course crushed in each case, and to regulate the thickness of the "strike," metal gauges are fixed alongside the paper tray, and in such position that the frame or chase containing the original, when down, shall rest upon them.

FIG. 1.



DIDOT'S POLYTYPE APPARATUS.

I will show you how easy it is to illustrate this method by means of an ordinary stamping press provided with a quick screw, but the diagram before you (Fig. 1) will give you an idea of a simple form of apparatus originally used, and which was constructed of hard wood. The arrangement of parts is sufficiently obvious without further explanation, excepting that it may be mentioned that the rod carrying the catch which releases the block should stretch from one standard to the other, the catch being taken out of the staple in the drop-block by putting the wire in torsion. This process is still in occasional use for the rapid reproduction of small typographic ornaments or blocks, but in such cases the matrix is generally a thick electrotype cast made from the original block. For initial letters or ornaments about an inch and a half square, there is probably no quicker or better method of reproduction than that of striking the matrix into semi-fluid type-metal.

At another period Firmin Didot adopted the plan of forcing the forme of type by dead pressure against a sheet of soft lead, and the matrix or reverse thus obtained served for obtaining printing plates by the method of striking into semi-fluid type-metal just described. I will show you how easy it is to obtain a reverse in soft sheet-lead by dead pressure, and also that if the lead matrix is placed in the ordinary stereotype casting-box, casts may be obtained from it in ordinary type or stereotype metal, these alloys melting at a lower temperature than the lead. In a similar way a lead matrix may be made by driving an ordinary type punch-ways into a piece of lead, and the lead matrix being adjusted to an ordinary hand-mould of the right body size, it is easy to cast a number of types in it, which are about as good as the original; this being often a very convenient process to follow when a few extra types are wanted in a hurry.

In the usual casting operations it is generally necessary that the mould in which the casting is made should be of less fusibility than the material cast, although there are rare cases in which this does not hold good; but in the case of the striking method just described, we have a method by which an impression may be obtained in a much more refractory material than the original matrix. For example, an impression in sealing wax taken from type may be quickly driven down on the surface of type-metal just on the point of commencing to solidify, and will yield a perfect cast in the alloy, and this I illustrate very easily by means of the quick screw-press before used. Similarly, a die in high steel may be made from a silver or copper coin, if the steel is heated to bright whiteness, and the coin, attached to a drop-hammer, is allowed to fall upon it. The main points to ensure success appear to be forming of the steel block as a blunt cone, so that the middle shall first come in contact with the original, and the protection of the hot steel from the action of the air till the last instant. I have seen dies made by this process at the works of the Phœnix Die Company, of Prince's-street, Blackfriars, so perfect as to recall the smoothness and perfection of an electrotype, and I was told it was no uncommon thing for mints to send coins in order to obtain fresh dies for the replacing of injured ones. The method of moulding by striking into soft metal is of great interest, and those interested in methods of typographic reproduction should bear in mind the possibilities of this method. If, for example, numerous small stereotypes in hardened steel were required, they could readily be obtained by the "striking" method, a steel die (itself, let us suppose, "struck" from an electrotype) being used.

Very much of interest and importance arose out of experiments carried on in the office of Firmin Didot, in Paris, about the end of the last century and the beginning of this. In the first place, the introduction of a hard type-metal containing copper, this being due to Herhan, at the time a workman in the employment of Didot, and the hard metal was introduced to enable the type to stand the strain of moulding by dead pressure against lead plates.

One of Herhan's alloys contained:—Lead, 25 parts; antimony, 15 parts; copper, 6 parts.

Another notable outcome of the work in Didot's office was the production of a matrix by punching the letters into it successively, a device of Guillot, another workman in the service of Didot. Guillot called his process "Graphitype," and he drove the steel type-punches successively into a copper plate, this plate being then used as a matrix for casting a stereotype. Guillot's method may be regarded not only as the parent of the various "type writer" methods of making matrix sheets or strips, but also of Herhan's next introduction —the use of matrix types.

It is easy enough to illustrate to you the principle of Guillot's "Graphitype" by driving these punches into the face of this copper plate, using a guide rule to keep the line, and then casting from the plate in the usual casting-box. In this form, however, it is hardly a practicable method, but its modern developments, in which a kind of type-writer is used to make a matrix out of wood (the end of the grain) or soft paper, may perhaps come into general use.

Herhan, whose hard metal has just been referred to, developed the idea of his fellow workman, and made it more practicable by setting up the page with matrix types instead of driving the punches into a plate of copper, this arrangement allowing corrections to be made, and also ensuring that the whole of the printing surface shall be in one plane. Herhan's types were of brass or copper, and generally similar to the ordinary types, but in place of the projecting or male letter of our ordinary type, was a female or matrix letter, just the reverse of the face of the usual type. Such letters, a few of which I have made and will hand round, are set just as ordinary types, excepting that they are arranged in the stick and chase non-reversed, and a proof can be taken on the press ; preferably, however, on thin paper, such as is used for copying letters, as the impression must be read through the paper if it is to be read non-reversed. Another way of taking a proof is to lay a sheet of plain paper on the "forme," and over this a sheet of black manifold paper, the coating of which sets off on the plain paper when the pressure is applied. The "forme" being locked up, and any large whites overlaid with special quadrats (or high quadrats may be used in the first instance) it is shut up in a casting-box, and the stereotype is made directly from it. Some of Herhan's matrix forms and casts were recently in the *Conservatoire des Arts et Metiers* at Paris, and are probably still there. Didot issued several books printed from stereotypes made by this method.

The "Linotype" system of Mergenthaler, in which a very cleverly designed machine brings a number of matrices into a row, so that a line is cast, may be regarded as in some sense a development of the idea of Herhan, and before you are specimens illustrating the "Linotype" method, for which I am indebted to Mr. Thomason, the Secretary of the Linotype Company.

Considering that in the case of newspaper work printing is always done from stereotypes, it seems to me that it would be a more reasonable and direct proceeding to set the matrices, and cast the required plate directly into the matrix forme, rather than to delay matters by the intermediate process of moulding. Although Herhan devised excellent methods of striking his matrix type quickly, and in true register, from the original punches; an engineer of the present day could do better: he could design a machine which would turn out brass or copper matrix types about as quickly as wire nails are cut off and headed, and the cost per pound of the matrix type possibly might not exceed that of ordinary types. Again, it is quite easy to make the matrix types radial, so that they can be "made up" in curved boxes, and plates for rotary machines cast as soon as the last lines are set or the final corrections made. On the table are a few radial matrix types which I have made. I cannot help thinking that the time is not far distant when Herhan's matrix type will largely replace those used now, and it need scarcely be said that the ordinary type-setting and distributing machines would be as available with these as with the sort of type now in use. It certainly seems absurd to set a "forme," and mould a matrix from it when it is just as easy to set up the matrix, and to cast directly into it.

Just at the beginning of this century we find A. G. Camus publishing a book on the methods of stereotyping, M. Camus being at that time reponsible director of the printing of the French national currency, and he was required to be present whenever work incident to the production of notes was in progress. This work* gives very interesting details regarding the earlier stereotyping methods.

During the first decade of the present century, several English printing offices, including the two University presses, adopted stereotyping, and self-called "inventors of the process" went about, offering to sell or divulge the process for various sums from £20 upwards. But in 1809, Charles Brightly, of Bungay, in Suffolk, published an English book giving full working details of the plaster process, the method described being practically the plaster process of the present time.† The plaster process of stereotyping was now established, and soon came into very general use for certain classes of work, and the next great step was the paper process, in which softened paper is forced down upon the original type "forme," and in the mould thus obtained one cast or more can be made.

In 1822, De Paroy, of Paris, published a small book‡ describing in short form the leading stereotype methods, and calling attention to his own improved method, which method was not described, but only its advantages alluded to. It fact, this little book was evidently intended as an advertisement of the author's new and secret process of stereotyping, and from what he says about it, one may pretty confidently suppose it to have been the paper mould process, but in the absence of definite information, it would hardly be the thing to credit De Paroy with the invention of the paper process. We find, however, the method fully developed in a French patent by Genoud, of Lyons, in 1829, but there were certainly several persons making use of it before this time, and since then it has become essentially the stereotyping method, and has ousted all other processes, except for special work. Among other things it has rendered possible the modern newspaper, and the facility which it affords for rapidly producing any required number of curved plates, suited for rotary machines, has revolutionised printing as far as rapid production is concerned.

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* A. G. Camus. "Histoire et Procédé du Polytypage et de la Stereotypie." Paris: Baudouin, An X. (1801.)

† "The Method of Founding Stereotype," by Charles Brightly. Bungay: 1809. Printed for Charles Brightly by R. Phillips.

‡ "Précis sur la Stéréotypie." Par De Paroy. Paris, 1822. Imprimerie Stereotype de Cosson.

Moreover, the process is so simple and so easy that any person may, for a cost of a few shillings, produce small stereotype plates equal in sharpness and general excellence with those made in the most perfectly fitted establishment.

At this point my historical sketch is brought to a close, as what is to be said about the origin of later or less important processes may be left over till the methods themselves are described; but I purpose, in this lecture, demonstrating the essential principles of the paper mould method, leaving details until next week.

Here is a pad of soft paper—it is built up of about twenty thicknesses of soft blotting-paper—stapled together at the edges, and a hard impression from a page of type is taken upon this pad. It is now placed between two slabs of dry wood, which slabs are separated, to a distance of something under a quarter of an inch, by strips of the same material, and melted type-metal is poured in at the top. On separating the slabs of wood, you see we have a fairly good cast of the original type, and the whole process of producing it has taken less than a minute. In practice, however, dry paper is not used for making the mould, but a number of sheets of paper are pasted together, and this combination is used damp.

Here are some sheets of paper—of the sorts and quality I will speak next week—and I paste them together with this soft paste. Here, on the other hand, is the soft pasteboard ready made (it is known to the workman as "flong*"), and having laid it on a warm and slightly oiled page of type, I beat the back with a stiff brush until the soft pasteboard has taken a perfect impression of the face of the type. On the back I now lay a piece of blanket, pinch the whole in a screw-press, the press having been previously warmed. The drying of the mould may under such circumstances take from a few minutes to half an hour, according to the temperature and the frequency with which the blanket and other packing is changed; but I have here a similar "forme" upon which is a mould already dry and warm. This being clamped between slabs of warm iron, metal is poured in, and a cast is obtained little if at all inferior to the original type in sharpness. Here, then, you have the essential features of the paper-mould process, and the next lecture will be occupied with the details of this the most important of all stereotyping processes.

In the room there are numerous specimens illustrating stereotyping processes generally, and more especially the paper process; also apparatus and plant. Many of these things have been lent by leading firms; and although special reference to most of them belongs rather to the following lectures than to this evening's subject, I will mention some of them now, and at the same time trust to the kindness of the lenders to allow them remain for the illustration of the subsequent lectures. Messrs. Richardson, Koolman, and Isger send a very extensive collection, which illustrates almost every branch of the work they carry out, and among the casts which they send is a curved stereotype of the special edition of the *Evening Standard* of to-day. Mr. James Dellagana, whose father was, I believe, the first to introduce the paper-mould process into this country, sends a set of specimens illustrating the various stages of the method of stereotyping. Similarly, Mr. Plummer sends illustrative specimens of several processes.

Among the apparatus for stereotyping, the very complete and compact plant of Messrs. Harrild and Sons deserves special notice, also the portable foundry of Messrs. J. M. Powell and Son.

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* In French sterotyping shops the form of the word is "flan," flan being a thin farinaceous cake sold in Paris. The origin of the word would have been less obscured if we had retained the French spelling, and pronounced the word according to the English usage.

Miscellaneous.

THAMES CONSERVANCY.

The general report of the Conservators of the River Thames, from the 1st of January, 1889, to the 31st of December, 1889 (ordered by the House of Commons to be printed July 9, 1890—No. 291) has been issued.

Though the accounts deal with larger amounts than the previous twelve months (£87,421, as compared with £85,287 for the Lower Navigation, and £26,297, as compared with £23,796 for the Upper Navigation), the report itself is much shorter than last year. Then the re-organisation of the inspecting staff was explained, the new orders for petroleum traffic were referred to, the improvements in craft and appliances for raising sunken vessels were noted, and the works for improvements in the upper navigation district carried out in conjunction with the Thames Valley Drainage Commissioners were mentioned in detail, with their cost. (See *Journal*, August 16, No. 1,917, which contains also some historic references to the work of the Board.)

The present report, under "Upper Navigation.—Staines to Cricklade," refers only to lock and weir improvements at Old Windsor, Sandford, Medley, and Streatley, and to the continual work of dredging. The section on Lower Navigation is, with one important exception, on the routine work for the year, which in its results may be thus summarised. Forty-five sunken vessels were raised. Eight convictions were obtained for infractions of the Explosives Act, and 77 for the discharge of rubbish and ashes into the river. Sewage works have been closely watched, and the provisions of the Acts which relate to the discharge of sewage into the river have been enforced, while house boats and steam launches have also been watched.

The important exception to reference to routine work is the statement respecting the continued sewage pollution from Staines. In the *Journal*, vol. xxxvii., p. 760, there was given a *résumé* of the work done by the Conservators since 1866, in serving notices for stopping the flow of sewage into the river, and obtaining convictions against owners of gas, chemical works, &c. One town after another within the time either originally fixed, or within the extension granted, diverted its sewage, till so far as the river above the intakes of the water companies is concerned, there remained, in 1888, only Weybridge and Staines that continued to send their sewage into the Thames. With regard to Weybridge, the Conservators "received assurances from the rural sanitary authority that they were taking all steps in their power to prevent pollution."

The case of Staines was a complicated one. The Conservators brought an indictment against the Staines Local Board for passing sewage into the river. The Board took steps to divert the discharge from sewers indisputably under their control, but they were unable to deal with cases where it was stated there was a prescriptive right in certain owners to send house drainage into a sewer. The case against the Board was heard before the Court of Crown Cases Reserved. The result was that the prescriptive right was upheld, and it was decised that the Board had no power to stop the right-owners either by injunction or action, nor to stop the sewer in question. The Court therefore ruled that no criminal offence had been committed by the Local Board, and that a verdict of not guilty must be returned. "It remained then only for the Conservators to endeavour to prevent those claiming the prescriptive right from continuing to pollute the river. The Conservators applied to the Staines Local Board for information as to the names of these persons." (Report for 1888.) The present report states that "to meet the difficulties in question the Conservators have caused samples of the discharge to be taken from a very large number of houses at Staines from which pollution is passed into the river." After analysis, the Conservators served notices, under their 1866 Act, on individual owners and occupiers, requiring them to discontinue the passage of sewage into the river within 13 months, this being the shortest time prescribed by the Act. At the expiration of the time "the Conservators propose to take proceedings against all those persons who have failed to comply with the requirements." Here the history of this case ends for a while.

It can be seen that by the time of the meeting of the International Sanitary Congress in London, next year, the Conservators may be able to announce not only as they did in 1881, that "the river above the intakes of the water companies is now practically free from sewage contamination," but that it is actually free from any systematic pollution whatever.

AGRICULTURAL RESOURCES OF PERU.

For centuries before the discovery of America, Peru was inhabited by an intelligent and highly civilised race of Indians. Forty millions of people were governed by the Incas, who ruled with justice, moderation, and wisdom. Agriculture was carried on very successfully, and every foot of arable land was under cultivation. The United States Minister at Lima, in his last report on the resources of Peru, says that even the sides of the Andes were terraced to secure more land, which was irrigated by water from the interior, and the remains of these hanging gardens can be seen to this day. An extensive system of public roads extended throughout the country, and public granaries and storehouses were established, where Government couriers and military expeditions could find refreshment. Gold and silver were not used as money, but found a place in decorations and in jewellery and small tools. In 1530, the Spaniards, under Pizarro, conquered the country, and for 300 years it was a province of Spain. The present population of Peru is about 2,500,000, consisting of Indians and their descendants, who form almost two-thirds of the population, and the descendants of Europeans, principally the Spaniards, with about 40,000 Chinese. Of the arable land in Peru about three-quarters of it is between the Andes and the coast, while the remainder is in the interior. All along the coast, which is generally sandy and barren, there are numerous small rivers which find their source in the snow-capped mountains and flow into the Pacific. It is in the valleys of these rivers that the principal part of the fertile land is to be found. Without the water for irrigating purposes the land would be worthless, but as it is an abundant supply makes it wonderfully productive. The land is ploughed in the following manner. From six to a dozen teams of oxen are put at work in a single field of about twenty to thirty acres. The oxen are yoked by tying a heavy beam across their foreheads. To this beam the plough is attached, all the force being applied by the head instead of the shoulders. The plough is a crooked stick or branch of a tree, the point faced with iron. The Peruvians contend that they do not need to plough more than two or three inches deep, simply enough to loosen the soil, so as to enable the seed to take root. Another peculiarity of every Peruvian plough is that it has only one handle. The driver carries in one hand a large goad, twelve or fifteen feet in length, with which to urge on his team, and he manages the plough with the other hand. When the field is ploughed, the next step is to make the irrigating ditches. These must connect with the *acequia* (canal) which brings the water from the river. These acequias traverse the field at a distance of three or four feet apart, and are six to eight inches deep. They are so arranged that the whole field can be instantly flooded by turning on the water, and every hill of corn or potatoes, or sugar cane will be thoroughly soaked. Maize grows everywhere, and fields of maize may be seen at any season of the year, and at almost every stage of growth. It is the staple food of all classes. The natives grind it between two stones, and the meal is mixed in a batter, when it is fried in the shape of pancakes, which are called *tortillas*. These are covered with a sauce made of lard and pepper, and rolled up in a size convenient to handle. It is from maize that the natives make *chicha*, the national drink of Peru. The corn is pulverised between two stones, and the meal is put to soak in water, and the mass is afterwards boiled. The juice is then fermented, and the result is a sour liquid resembling, to a certain extent, weak cider. The potato is a native of Peru. When the Spaniards first visited the west coast of South America they found this esculent cultivated by the natives, although it grew naturally in uncultivated places, wherever a sufficient degree of moisture enabled the plant to live. Tradition has it that it was on the top of Mount St. Lorenzo, the island in the harbour of Callao, where the Spaniards found the first potatoes, and from which they took the seed to Europe. Coffee is grown successfully in the warmer portions of Peru, and the article produced ranks high whenever it comes in competition with either the Brazilian or East Indian article. The amount produced is sufficient for home consumption, although but little is exported. The reason given for this is that the skilled labour required to prepare the berry for market is difficult to procure, and sufficient capital has not yet been invested in the business to make it remunerative on a large scale. Clover is not grown in Peru, but the tropical substitute, alfa, is raised in immense quantities. Alfa is the universal food for cattle, sheep, goats, horses, mules, and donkeys. The great agricultural industry of Peru, and the one that the country appears best adapted to, is the growth of the sugar-cane. The climate and soil appear to be particularly suited to the cultivation of the cane. The cuttings require two years to come to maturity, and then the plants in the latitude of Lima may be cropped for three years in succession without renewal. In the sugar country in the north of Peru the cane roots are cropped for six successive years without being renewed. Another great advantage is in the equable climate, which enables the farmer to leave his cane standing until he is ready to grind it. There is never any fear of frost, and if the cane is maturing too rapidly he has only to keep off the supply of water, when the progress of ripening is instantly suspended until it suits the convenience of the farmer to have it proceed. Labour also is cheap; from 1s. 8d. to 2s. a day is paid, the labourers boarding themselves. Formerly the labourers were coolies and slaves; they were brought here in great numbers from China, but the emancipation of slaves in 1874 put an end to slave labour, and since then the coolies have been scattered throughout Peru, and have engaged in all kinds of work. The maximum annual product of sugar in Peru has been as high as 100,000 tons, but for several years past the annual export has not exceeded 50,000 tons. In addition to this, about 20,000 tons are manufactured every year for home consumption. The principal sugar country is in the valleys of Lambayeque and Chicama, in the north of Peru, although there are several large plantations in the valleys of the Rimac. The smaller ones average from 1,000 to 1,200 acres. Many of them are fitted up with narrow gauge railroads, and they all have the improved machinery for making sugar. From the juice of the cane immense quantities of rum are manufactured, and this is used for fuel in small cooking-stoves, and also for illuminating purposes; but it is largely used by the natives in the mountainous regions as a beverage. This liquor is made in various degrees of strength, and as the cane is easily grown, the manufacture of rum is only limited by the demand. It is sold in Lima and the villages at about sixpence a quart. If Peru is the natural home of the sugar-cane, it is also the centre of a very large grape-growing industry. Whole districts are devoted to grape culture, and the United States Minister says that if sufficient money were invested in the business, the wines of Peru would probably soon rival in the markets of the world the far-famed products of France. The annual product of wines is estimated at 400,000 barrels, valued at £833,300. From the Italia, or white grape, a very choice brandy is distilled, which commands a high price. The ordinary white grape of the country produces a similar but inferior liquor, which is known as *pisco*. The cultivation of coca is extensively carried on in the interior, but exact figures as to the amount and value of the crop are difficult to obtain. This is the plant which produces cocaine. It grows wild in the mountains of Peru and Bolivia, and is cultivated in districts elevated from 2,000 to 5,000 feet above the sea. It is valued for its stimulating narcotic properties, which it is said to possess in a greater degree than opium, tobacco, or any of the vegetable productions. The leaves are gathered and dried in the sun, and are chewed mixed with quicklime. There is a factory in Callao and one in Lima, where it is manufactured nto cocaine. It has been cultivated in Peru since the time of the Incas, and the principal depots for it are at Húanuco, Ayacucho, and Cuzco, in the interior.

THE FORESTS OF BOHEMIA.

Bohemia, in spite of its dense population, belongs to the well-wooded portions of Europe. There are 1,474,518 hectares under forest (hectare = 2·47 acres), the whole surface of the country measuring 5,195,426 hectares, consequently 28·4 per cent. of the entire area of Bohemia is covered with forests. The per-centage of the wooded surface in the whole Austro-Hungarian monarchy does not vary much from that of Bohemia, being 29·8; this per-centage in Europe is only exceeded by Russia, including Poland and Finland, and by Sweden. All the other European countries fall below the Austrian average, Great Britain having the lowest per-centage of forests. The United States Consul at Prague says that the question has recently been raised and discussed whether the area under forests in Bohemia has been increasing or decreasing within the last century. From reliable official surveys, it appears beyond question that in consequence of the progress of agriculture, and the more varied uses of the soil, and of the increased demand for lumber, the forest area has been decreasing in Bohemia the same as in other European countries. It has been ascertained that in the twenty-five years from 1850 to 1875, there was an actual decrease of 33,212 hectares, or 2·20 per cent. of the entire area under forest. This loss is not inconsiderable, occurring during a period when forest culture had reached a high degree of development, and the importance of the preservation of forests had been generally recognised. It is to be observed that there was a decrease of the forests owned by small proprietors (8·74 per cent. of the whole area) and by corporations (2·48 per cent.), whereas the large domains show in the same period a slight increase. According to their nature, the Bohemian forests present the following division:—Pine forests, 1,205,530 hectares, or 81·7 per cent.; leaved, or hard forests, 89,731 hectares, or 6·1 per cent.; and mixed forests, 179,257 hectares, or 12·2 per cent. Of coniferous trees the prevailing species are the spruce fir, the pine, and the larch. The spruce predominates, covering, in most parts of the country, over 50 per cent. of the forest area, and in the mountains fully 80 per cent. Of deciduous trees the prevailing species are the beech, the oak, and the birch, together about 87 per cent. of the whole; the alder, the chestnut, elm, poplar, aspen and basswood divide the rest among themselves. The forests of Bohemia are officially classed, according to ownership, as follows:—Forests belonging to large domains, 920,458 hectares; small proprietors, 277,810 hectares; common and corporate forests, 276,250 hectares. The category of large domains embraces all estates of entail and in fief or feudal estates, and all such allodial estates as contain over 115 hectares. The category of small proprietors includes allodial estates whose area is less than 115 hectares. In the category of common and corporate forests are included those forests which are the property of communes and of the church, and also such as belong to schools, endowments, and foundations. Of this class of forest about 70,000 hectares belong to churches, convents, and bishoprics, whereas schools only hold 1,148 hectares, different endowments 29,273 hectares, and the rest belongs to communes. There are no forests in Bohemia owned by the State, except the domain of Joachinisthal, with an area of 5,470 hectares under forest. Common forests cover an area of a little over 180,000 hectares. The city of Pisek stands at the head of the communes possessing forests, being the owner of 5,763 hectares of forest land in good condition. Bergreichenstein comes next with 4,700 hectares; Pilsen, Elbogen, and Joachinisthal hold over 3,000 hectares each. Other communes have less than that amount of forest land. The population enjoys only very limited privileges in common forests. On certain days, usually twice a week, the poor are allowed to gather dry branches and twigs lying on the ground, but they must not break any twigs or branches, or use carts or any kind of vehicle for the purpose. For this slight privilege they are frequently required to help in the spring about a week in the work of forest planting without pay. The picking of mushrooms in forests is generally allowed, but the raking of leaves for litter is not permitted, these being left to rot in the woods and serve as manure. Pasture is not allowed except to the forest keepers, and then only in places where no injury can be done to the forest culture. Since the abolition of the right of common usage, pasture is also generally disallowed in the woods of private domains. Persons who own buildings in which a vested interest in the common property attaches, receive yearly a certain amount of fuel, as well as the timber necessary for the repair or rebuilding of their houses; and the owners of houses to which no such vested interest attaches usually receive more or less fuel at a moderate price. The poor are furnished with a certain quantity of fuel from the common forests without payment.

RUSSIAN COAL PRODUCTION.

The *Russie Commerciale* has recently published some particulars respecting the working of the Russian coalfields. According to this publication, the quantity of coal produced in the different countries is distributed as follows:—England, 166,000,000 tons; United States, 118,000,000 tons; Germany, 76,000,000 tons; France, 21,000,000 tons; Austria-Hungary, 22,000,000 tons; Belgium, 18,000,000 tons; Russia, 5,500,000 tons; and other countries 5,000,000 tons. According to this, Russia only occupies a very secondary place among coal-producing countries, and yet Russia is the richest country in coalfields. Rich coalfields are found in the governments of Moscow, Riazan, Toula, Poland, Caucasus, and particularly in the basin of the Donetz. Coalfields which have up to the present remained unworked are found in the Island of Sakhaline, Western Siberia, in the neighbourhood of the Oural, in the Kirghish Steppes, and the plains of Turkestan; but it is particularly the basin of the Donetz which is remarkable for its coal wealth. According to the estimates of Professor Mendeleïew, the surface of the ground occupied by the coal beds in this province extends over nearly 30,000 square kilometres, or 11,580 square miles. Taking the average figure of 50,000,000 pouds (a poud is equivalent to 36 lbs. avoirdupois) to the square kilometre, it will be found that the general yield of coal will amount to the total of 1,500,000,000,000 pouds, or 24,000,000,000 tons. The entire world, says Professor Mendeleïew, might be supplied during the next fifty years with coal from the Donetz basin. The above remarks apply only to the superficial beds; as regards the others, which are at considerable depth, and which have not yet been worked, they are said to be even of greater richness. The working of coal lying at great depths can only up to the present be considered as an experiment, and the same may be said of the beds situated in the Kerghish Steppes, in the governments of Tomsk, Caucasus, Turkestan, and the Island of Sakhaline, where the working is in a very elementary state. Coal mining has received a very considerable impetus in Poland, and in the basin of the Donetz. In 1888, Poland yielded 142,000,000 of pouds, and the basin of the Donetz 140,000,000 (2,290,000 tons and 2,258,000 tons respectively). Although the working of coal is rapidly on the increase, the quantity extracted is not sufficient for the requirements of the country, which is obliged to have recourse to foreign importation. In spite of its immense coalfields, Russia imports annually nearly 107,000,000 pouds of coal (1,726,000 tons), of which 85,000,000 pouds are supplied by England, 19,000,000 by Germany, and more than 2,000,000 pouds by Austria-Hungary. Russia, in addition, consumes enormous quantities of wood for her various industries, and this leads in a great measure to the destruction of her forests, with all its disastrous consequences. In spite of its good qualities, Russian coal cannot compete with foreign coal, even in the southern ports, which are found in proximity to the coalfields of Donetz. Notwithstanding the increase in the duties on importation of foreign coal at Odessa, Sebastopol, and in the other ports of the Black Sea, English coal is no dearer than Donetz coal, and far from diminishing, its importation has greatly increased of recent years. "This proves," says the *Russie Commerciale*, "that the demands of the various industries for coal increase more rapidly than the working of this combustible in Russia, and that the condition of the means of transport is far from satisfactory."

DISTRIBUTION OF POWER AT NIAGARA.

The scheme for the distribution of power from the Niagara river to a number of factories at Buffalo, and also through a new manufacturing town to be built near the falls, has taken definite shape. A piece of land has been acquired some distance above the falls on the American side, and a very strong syndicate is now engaged on the project. Although it is proposed to develop a very large amount of power, the water abstracted from the river will be a very small proportion of the whole, and its loss will not be noticeable. Four per cent. of the flow of the river would provide 120,000 horse-power, assuming that only 140 feet of the actual 200 feet were utilised. It is intended to divert the water by a lateral canal, and to allow it to descend vertically in shafts, in which turbines will be placed, and then to discharge it by a tunnel tail-race passing below the present town of Niagara. The turbines will be of a size beyond anything yet attempted, and will work under constant conditions. As the town of Buffalo is 18 miles distant from the falls, the power will have to be transmitted to it by some means yet to be determined. The choice lies between rope transmission as at Shaffhausen; transmission by compressed air, as at Paris and Birmingham; by pressure water, as in

London; and by electricity. The choice amongst such methods of those which are most economical and most likely to suit the wants of millowners, requires very careful consideration. Hence the Cataract Company have resolved to invite from certain selected engineers and engineering firms plans for the utilisation, at Niagara, of 120,000 horse-power, and to submit the plans for an authoritative opinion to the judgment of a scientific international commission. The commission will consist of Sir William Thomson, F.R.S., as president; Professor Mascart, member of the Institute, and director of the Bureau Central Météorologique, Paris; Colonel Theodore Turrettini, who was director of the works of the St. Gothard Tunnel, and is director of the works for the Utilisation of the Motive Power of the Rhône at Geneva; and lastly, Dr. Coleman Sellers, formerly of the firm of Messrs. Sellers and Co., of Philadelphia, and now professor of engineering at the Stevens Institute, Hoboken, and at the Franklin Institute of Pennsylvania. Professor W. C. Unwin, F.R.S., M.Inst.C.E., is the secretary to the commission.—*Engineering.*

CEREAL AND WINE PRODUCTION OF ROUMANIA.

Roumania is an essentially agricultural country. Out of a total area of 12,000,000 hectares (30,000,000 acres), nearly a third—that is to say, 10,000,000 acres—are devoted to cereal cultivation. The *Journal de la Chambre de Commerce de Constantinople* says that the crop most extensively grown is maize, which covers an extent of 4,559,000 acres, and furnishes the principal food for the Roumanian peasant. After maize comes wheat, the cultivation of which covers more than 2,470,000 acres, and the yield of which in 1886 was over 55,000,000 bushels. Following in the order of their importance come barley, oats, rye, millet, colza, and flax. In less than ten years the export of cereals, wheat, maize, barley, and rye has doubled, and the sum annually produced to the country by their sale varies between £4,000,000 and £8,000,000 sterling. In 1886, the latest year for which the statistics are available, the value of the exports of cereals and oleaginous seeds exceeded that of the imports by £7,000,000 sterling. Although all the lower territory in Roumania is adapted to the cultivation of cereals, it is particularly in the vast plains of the two Wallachias—immense tracts of country almost devoid of trees, and where no undulation throws any shade over the cultivated lands—that cereals properly so-called are found in the greatest abundance. In Moldavia, where the ground is more undulating, and where the hillocks lend themselves more readily to more varied descriptions of cultivation, the proportion of land under grain cultivation shows a considerable falling off, while there is a much larger extent devoted to pasture land. Thus spread over the whole extent of the country, the production of cereals has actually no central market. For local requirements there are markets in certain towns, such as Craïova, Bucharest, Berlad, and Jassy, for example; but for the export trade it is at the ports of shipment, Braïla, and particularly Galatz, near the mouths of the Danube, that the grain business is conducted. As regards the wine industry, Roumania exports wines to the value of £480,000. This only represents a very small proportion of the total production of the country, which in 1887 amounted to 8,726,004 hectolitres (hectolitre = 22 imperial gallons), representing a value of more than £8,000,000 sterling, and derived from nearly 405,000 acres of vines. The common Roumanian wine sells on an average for 35 francs the hectolitre. If the wines of Roumania are arranged according to the order of their prices ruling in the country itself, it will be seen that the Wallachian wines occupy the first place, those of Moldavia the second, and the wine produced on the hills in every case is superior to that grown on the plains. The vineyards are classed according to the quality of the wines they produce. The superior quality of the wines of the high lands is due, first of all, to the varied composition of the soil, and in the second place to the situation, the altitude, and finally the varieties of the vines. These latter wines are of greater alcoholic strength, have less tannin, and a little more acidity than those of the lower lands; they combine, moreover, qualities which are highly appreciated. The amount of alcohol in the Roumanian wines is comprised between 4 and 18 degrees; it averages from 10 to 11 degrees. Taken as a whole, the Roumanian wines have a great affinity with those of Austria-Hungary, the Rhine, and Roussillon. In Wallachia, the principal wines in the high lands are those of Dealu-Mare, in the department of Prohova, and of Dragasani in the department of Romnicu-Valcea. Mention should also be made of the wines of Golul Drancea and Orevitza, which places are situated near Turn-Severin in the department of Mehedintzi. In the region of the plains are found the wines of Plenitza, Simnic, and Carcea, in the department of Doljin, not far from Craïova; those of Rogova, Bresnitza, and Poroïna, produced in the lower part of the department of Mehedintzi; those of Greaca and Popesti in the department of Vlasca, and of Draganesti in the department of Oltu, and, finally those of the department of Romanatzi. In Moldavia the best wines are those grown on the hills in the department of Jassy, and particularly the white wines of Cotnari and Socola, and the white and red wines of Odobesti, in the department of Putna. Then come the wines of Nicoresti, in the department of Tecuciu; of Panciu, in the department of Putna; of Sarata, in the department of Buzeu; of Vertescoin, in the department of Romnic-Sarat; of Dragasani in Tecuciu; of Greaca and Costesti in Tutova; of Husi, in the department of Vaslui; and, finally, the ordinary wines which are produced in such great abundance in the department of Covurlui. To complete this list mention should be made of the Dobrudscha wines, which are produced in the environs of Isakca, in the department of Tulcea.

MANUFACTURE OF WOOD PULP FOR PAPER MAKING IN FRANCE.

The British Vice-Consul at Dieppe says that at Bonne Nouvelle there is a mill for the manufacture of wood pulp for paper making. The pulp is sold to paper mills in France, and mostly used, together with rags, for the manufacture of various kinds of paper, from wrapping paper to superfine writing paper, but this pulp is so far different from others in the market that not only can good printing paper but also a high class of writing paper, and other superior kinds of paper, be manufactured out of it without the addition of rags, and the samples of writing paper have, it is said, very much the appearance of paper made of linen rags. The manufacture is a simple one. The wood is the usual white wood from Sweden and Norway, or Finland, as no suitable wood can be supplied in large quantities from the neighbourhood. It is shipped in round logs of from two to six feet in length, and three to twelve inches in diameter. The first operation is to remove the bark and clean the outside of the wood, which is done by women, as it has been found that women are more suitable for this work than men. The logs are afterwards cut into flat pieces of about two inches and a-half in thickness. The knots are then, as far as possible, bored out by machinery, but any remaining knots are cut out by hand. Great attention is paid to cleaning the wood, in order to obtain a pulp clean enough for good kinds of paper. The cleaned wood is fed into a cutting machine, which rapidly chops it up into pieces of about half an inch in length. A band carries the cut wood to the top of the boiling-house. The boilers are of iron, covered on the inside with lead to protect, the iron from the action of the sulphurous acids used. The boilers are filled with wood through an opening at the top, and then a liquid, containing bisulphate of magnesia, is poured in to cover the wood. The boiler is then closed with a cover, and boiling is now done with steam, the time varying from ten to twelve hours. When the boiling process is finished, the steam is blown off, and the pulp forced through a valve at the bottom of the boiler into a tank with a perforated bottom to allow all liquid to drain off. The incrustating and foreign substances in the wood having been dissolved by the boiling process, the mass is now a soft white pulp, consisting of fibres of wood. After being washed, this pulp is ready for paper making, and, for facility of transport, is formed by machinery into rolls of a kind of rough thick paper, which are forwarded to the paper mills, and contain about 50 per cent. of water. The process used is known as Ekman's sulphite process, and the chemicals—a solution of bisulphate of magnesia—are prepared by leading the gases from burning sulphur over magnesite, water being admitted at the same time. The magnesite (carbonate of magnesia) is a kind of stone which is found in large quantities in Greece, and imported from that country. The sulphur comes from Sicily. Vice-Consul Lee Jortin says that the mill is at present worked on a small scale, turning out only about 100 tons of pulp a month, but being situated near the new docks, it is advantageously placed for the import of wood, sulphur, and magnesite, and, with cheap labour, it is likely that it will be enlarged, and that this new industry will become of some importance to the trade of Dieppe.

COFFEE IN GUATEMALA.

Coffee is the principal staple commodity of the Republic of Guatemala, and its chief article of export. The topographical features of the country are such that climatic influences are favourable to the growth of the berry, varying only according to altitude and care in cultivation, or as the degree of tropical heat may be tempered by copious rainfall, and precautions as to shade during the early age of the tree. The United States Consul at Guatemala says that in cultivating coffee, a nursery is formed by the choice of a level piece of virgin ground, in proximity to water, where the earth is rich. The land must be thoroughly cleared, and the soil dug to the depth of at least nine inches, and made as friable as possible. It is then divided into beds, with narrow paths between. The seed, carefully selected from the soundest grains, either in parchment or with their outer husk, should be sown, row by row, about ten to twelve inches apart. A rope, the length of the beds, stretched from one end of the same to the other, is used for this purpose. The seed, if sown in suitable weather (April being the best month), makes its appearance in the tender blade above the surface after thirty-five to forty days; so that a nursery formed during the month of April of one year has plants sufficiently matured to be set out during May or June of the following year. Preliminary to the all-important progressive step in coffee culture, that of transplanting, is "holing." The field is prepared in advance for the reception of the nursery trees by digging holes (five yards apart when above 3,000 feet above the sea, and three yards when at the lower levels of from 2,000 to 1,500 feet above the sea) to depths of about twelve inches by twelve inches in width. It has been demonstrated, by frequent experiment, that leaving the holes open for three or four months is chemically beneficial to the soil. In the matter of transplanting, the actual placing of the infant trees into the holes prepared for their reception is one that requires the most care and attention of all the operations in the formation of a coffee plantation. Early planting, during the month of May, June, and July, is desirable, because the trees have the benefit of the entire rainy season, and are sure to give a larger maiden crop. Coffee trees usually bear abundantly one year and lightly the next. Judicious pruning helps to increase the crops, although no definite rule can be given for pruning old trees further than that no branch should be allowed to yield more than three crops. The average product per acre in Guatemala of coffee cultivation is 1,800 lbs. In the preparation for market, the berries are always picked by hand and carried to the curing house, where the pulp is removed by machinery and placed in a water-tank, where the bean is never allowed to remain beyond a period of twenty-four hours. After the saccharine scum which covers the bean is washed off, the contents of the tank are turned out upon large drying grounds of cement, called *patios*, upon which the coffee beans are thinly spread. It is important that the coffee shall be constantly turned until all the surface is dry, and the beans cease to adhere to each other, while care is taken not to break the parchment whilst exposed to wind or sun, as every hour's exposure to the atmosphere, after removal of the parchment husk, takes away both the colour and aroma of the bean. When the beans are thoroughly dried and hulled, the sorting operation commences. Generally "firsts," "seconds," and "thirds" are prepared for packing into Dundee or Calcutta sacks of 130 to 135 lbs. net each, and upon its completion the coffee is ready for transportation on the backs of Indians or mules, or in carts drawn by oxen, to the nearest railway station for the most convenient port of shipment. The largest bulk of the "firsts" finds its way to London, the "seconds" to Germany and France, and the "thirds" to the United States. The labour on the coffee plantations is performed by the Indians of the country, whose remuneration varies from 19 to 25 cents in Guatemalan currency. The Indians subsist on *tortillas*, a corn cake, and *frijoles*, the bean of the country, both corn and bean being grown by their own labour on patches of ground on the squatter system, which belong to either the owners of the estates where they are employed, or are unsold Government lands which are thus gratuitously appropriated.

PRODUCTION AND CONSUMPTION OF BEER IN MUNICH.

Munich, says Her Majesty's Secretary of Legation in that city, stands at the head of the Bavarian beer production, export, and consumption. At the beginning of the century it already possessed seventy-two small breweries, while in 1876 there were only twenty-eight large breweries for brown beer, but these produced more than one-tenth of the whole of the Bavarian brown beer, the greater portion being consumed in Munich itself. The Munich consumption in 1876 amounted to 122 gallons per head per annum, the highest proportion, it is stated, in the world. But as foreigners in Munich are not reckoned, the true figure was somewhat lower. In Vienna the consumption was 65 gallons, in London 56 gallons, in Berlin 52 gallons, in St. Petersburg 15 gallons, and in Paris 3 gallons, at the same date. In 1888, the consumption in Munich was 130 gallons, while for the whole of Germany it was 35 gallons; and in 1889, the proportions were respectively 127 and 34 gallons. In 1879, the quantity of malt used in the production of beer in Munich amounted to 13,619,672 gallons, the quantity of brown beer produced amounted to 29,763,274 gallons, and the quantity consumed to 25,029,532 gallons. In 1889, the quantity of malt consumed amounted to 29,271,220 gallons, beer produced 64,396,684 gallons, and the consumption of beer, 35,324,102. Since the year 1879, the export from Munich has increased five-fold, while the consumption has only increased a little more rapidly than the population. Munich has the lion's share of the beer export of Bavaria. In 1869, the Munich export was only 583,154 gallons, and in 1872, 1,308,274; the export in the twenty years comprised between 1869 and 1880 has increased five hundred-fold. The large Munich breweries do not produce more than 2·1 hectolitres of beer from each hectolitre of malt, although the official calculation is 2·24 to 1. The reason given is that the public demands from the Munich breweries a good and relatively strong beer, and that beer for export in particular must be strong in quality. In 1889, there were in the Munich district 184 private breweries, 2 communal breweries, and 12 brewery companies. The private breweries produced 51,194,000 gallons of brown beer, the communal breweries 245,520 gallons, and the brewery companies 29,128,550 gallons. White beer is also largely drunk in Munich and throughout Bavaria, but only by the lower classes. Memmingen is the great centre of the white beer production. In the district of Memmingen, 1,973,994 gallons of white beer were brewed in 1888, and in the district of Munich only 789,184 gallons.

General Notes.

Cheese.—Although about 100,000 tons of cheese are made annually in the United Kingdom, nearly an equal quantity is imported from abroad, chiefly from North America and Holland. The foreign imports almost double each ten or fifteen years. In 1850 we received 347,803 cwts. of foreign cheese; in 1860, 583,283 cwts.; in 1870, 1,041,281 cwts.; in 1880, 1,775,997 cwts.; and last year, 1,908,000 cwts.

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CANTOR LECTURES.

STEREOTYPING.

By Thomas Bolas, F.C.S., F.I.C.

Lecture II.—Delivered February 24th, 1890.

Working Details of the Paper-Mould Process.

This method—the details of which form the subject for this evening—is essentially the important stereotyping process of our time, and it therefore well merits a whole lecture, especially as at present workmen often so far follow the traditions of their craft as to lose sight of such points of special advantage as might easily be grasped, if tradition were allowed to give way more freely to thought and experiment.

Here is the page of type, or "forme," which is to be moulded, and instead of being locked up in the chase surrounded with the ordinary wooden furniture, we have a type-high border about 3-8ths of an inch wide around it, but the face of this type-high border does not come quite close up to the type, there being a space of 1-8th of an inch between them. This type-high border is ordinarily obtained by surrounding the forme with strips of type-metal called "clumps," or "stereo-clumps," these clumps being type high, and about half an inch wide, but a bevel on the edge placed next to the type reduces the face-width to about 3-8ths, and gives the clear space of about 1-8th of an inch or so between the face of the clump and the type. The object of the clumps is to form a level bed for the strips of metal—commonly called "gauges"—which determine the thickness of the plate. The space between the type and the face of the clump leaves room for the saw-cut if the plate is to be trimmed close, or for the bevel if the plate is to be trimmed for mounting with catches on a metal block.

Now the forme should be planed level, not too tightly locked up, and its face must be slightly but completely oiled, this being done by rubbing it with a flat brush, not too heavily charged with oil, the brush being about as stiff as an ordinary hat brush. The traditions of the craft ordain that the oil should be the finest olive oil; but as a matter of fact, neither olive oil nor cotton-seed oil, which is now commonly sold as olive oil, is the most suitable, as these oils—and more especially the latter—are saponified very readily by any trace of alkali which may remain on the forme. A much more suitable oil is the very thin mineral lubricating oil which is sold retail at about 1s. 6d. a gallon. Here is a case in which an article sold at the lowest price is the best, and in connection with stereotyping—as indeed with most industries—there are many such cases; so much so that one must look with suspicion on the common but vague instruction to "use only the very best materials." The practical interpretation of this is to use just those samples for which the shopkeeper chooses to charge the highest prices; and when such an instruction is given as generally applying to all materials used in a craft, one may perhaps reasonably suppose that it is given because the instructor's knowledge of the materials is too uncertain for him to specify what qualities are desirable. Generally speaking, the forme is slightly warm when oiled; if it is cold and damp the oiling is almost certain to be unsatisfactory, and the mould may adhere to the type.

We now come to a very important matter, the flong and the materials used in its preparation. First, let us take the paste used to cement the various layers of paper together, and as to this matter one finds in the usual instructions merely a confusing crowd of recipes without the smallest indication as to choice between them, and some of these recipes order the use of materials the special service of which it is very difficult to conjecture.

As an adhesive, ordinary gum (arabic or acacia gum) is undesirable; it penetrates the substance of the paper, tends to make it unmanagably hard and brittle when dry, and, weight for weight, it gives less adhesion between sheet and sheet than is the case with starch or flour paste. Gum is especially bad in relation to the fine tissue which forms the face of the flong, as in penetrating this, it not only tends to adhesion with the type, but where the gum has penetrated, the face of the cast obtained will have a rougher texture than elsewhere. In addition, gum is expensive, and, what is perhaps worse, very variable in quality.

Starch paste is a very good adhesive, as its water principally penetrates the sheets, leaving the starch where most wanted, and that sponginess which is a characteristic of good and useful flong is retained.

Good as simple starch paste is, a paste made from a moderately glutinous flour, such as wheat flour, is better, as the gluten gives the starch greater consistency and adhesiveness without other disadvantages. Moreover wheat flour paste is easier to prepare and to manipulate than starch paste, and, if measured by adhesive power, is very much cheaper. Moreover, it penetrates the paper even less than starch paste. Altogether the advantage rests with wheat flour paste as the main adhesive.

Glue (the term includes gelatines and sizes) by itself is not a very suitable or desirable adhesive to use, as it is subject to the same disadvantage as gum arabic as regards penetration of the paper, yet in a lesser degree; but when used in conjunction with sufficient flour paste, the penetrating quality is eliminated, and owing to the setting of the glue the flong acquires increased sponginess, and also the valuable quality of being more rapidly compressed by the face of the type when the metal is warm, as the glue melts and consolidates the compressed parts. In addition, by the use of glue along with flour paste, the flong becomes capable of holding rather more water without becoming flabby, and where the flong is not compressed, it dries more spongy than would otherwise be the case. There is advantage in using glue with the paste, whether the type is to be moulded cold or warm, but very especial advantage in the latter case. The sort of glue most suitable is the soft and degenerate glue sold retail in the oilshops at 4d. per lb., high-priced hard glues and fine gelatines being very much less suitable. Instead of using glue, it saves time to purchase size, but care should be taken to use the low-priced size sold as common size (14 lbs. 1s. in London oilshops), and not the harder and finer size known as "patent size."

We may then dismiss all adhesives but flour paste and glue; the former can be used by itself, but glue by itself is not very satisfactory. Together they give the best result, for reasons already stated.

It is desirable to mix some mineral matter with the paste, and for this use we find, among other additions, the following recommended:—Whiting, litharge, white lead, kaolin, other clays, Paris white, zinc white, barytes white.

The use of the mineral matter is two-fold. It makes the compressed parts of the mould more hard and stony than they would otherwise be, and less subject to blister or scale during drying or casting, and it makes the uncompressed parts of the flong more spongy and uniform in texture. At the same time it makes the whole mould more resistant of heat.

Of the above, the only very definitely objectionable substances are litharge and white lead, as owing to the moisture and heat the lead poison is specially liable to be absorbed into the system of the workmen; and of the rest, whiting seems to me the best, its softness of texture, fineness, and the ease with which it is compressed, enabling it well to fulfil the double function as stated above. At any rate, I am quite sure that not one of the above is superior to whiting; whiting, moreover, is cheap and easy to get.

We now come to the preparation of the paste. Into this iron pan I put—

Whiting	6 lbs.
Water	20 lbs. (2 gallons.)

If the whiting is allowed to remain in the water for an hour or two it will be found that the lumps have completely broken down, and the mixing will be easy, a point I can illustrate by mixing up a similar batch, which was set by to soak before the commencement of the lecture. If, on the other hand, I try to mix this whiting which has only just been put in the water, it works into clots and becomes unmanageable. The hands form the most convenient tools for mixing the whiting and water, as also for working in the next addition:—

Wheat flour............	4½ lbs.

This being thoroughly incorporated, the pan is set over the gas for the mixture to boil, it being constantly stirred with a wooden stirrer, having a T-shaped head which can be kept in motion close to the bottom of the pan, and so eliminate all chance of burning. As soon as the mixture boils the glue or size is added:—

Soft size	14 lbs.
or	
Common glue....	$3\frac{1}{2}$ lbs.
Water	$10\frac{1}{2}$ lbs (a gallon and nearly half a pint)

The glue to be soaked in the water till quite soft.

In order to give the paste such keeping qualities as shall ensure the mass keeping good for years, four ounces of phenol* (carbolic acid) are now stirred in, and all that remains to be done is to work the mixture through a sieve having about twenty meshes to the linear inch, or it may be strained through a piece of net.

Three sorts of paper are used in making the flong. First, a fine hard tissue paper for the face; secondly, blotting paper to form the porous body; thirdly, stout and tough brown paper for the back, to give strength and to support the blows of the beating brush. It is of very great importance that the tissue paper which forms the face of the flong should be strong and fine in fibre, uniform in texture, and free from holes, all qualities which add to the expense of a paper, and any expenditure which secures the above is well bestowed, any economy on this score being bad policy. A tissue which becomes pappy and soft when in contact with the paste, or which allows its exudation through holes, may cause adhesion between the forme and the mould, with the attendant delays and disadvantages. The tissue papers sold for pottery transfers are generally very suitable for stereotyping, and some makers supply a special kind. The sort I am using is sold at Lloyd's paper-office in Crown-court, at 11d. per lb., and it is made to a special size, 24 inches by 56 inches, so as to be suitable for newspaper work.

As regards the blotting paper, the cheaper sorts answer as well as the more expensive, and I do not think the lowest priced papers contain irregularities or lumps so pronounced as to be disadvantageous. That which I am using is demy paper, weighing 23 lbs. to the ream, and costing 10s. 6d. per ream.

The brown paper for the back of the flong should be made of tough, strong fibre, free from knots and lumps; moreover it should be soft, and not heavily rolled. Such a paper is expensive, costing about 4d. per pound; but, as in the case of the tissue, it is poor economy to use a backing paper of unsuitable character.

I will now prepare some flong, the materials being:—

	Approximate weight in grains.
Brown paper (1 square foot)	200
Blotting paper, 3 thicknesses (3 square feet)	355
Tissue paper (1 square foot)	25
	580

The brown paper is laid flat and pasted uniformly by means of a rather soft, flat brush, the paste being, by preference, slightly warm, on account of the glue it contains, although with the above-mentioned proportions it is possible (though undesirable) to work it cold. A sheet of blotting is now laid on, and the pasting is repeated between each layer of paper, but in the case of the last pasting, which holds down the tissue paper, only a small quantity of paste should be applied, and that as uniformly as practicable. A convenient way of laying down the tissue paper is to roll it on a wooden cylinder, and then to roll it off this on to the pasted surface; and all through the operation great care should be taken that no paste comes in contact with the outside face of the tissue; generally speaking, the wooden roller requires wiping after each use. Close contact of the several constituent sheets of the flong is best insured by laying a clean paper over it after each addition, and rubbing down with the hand, or with a cloth folded so as to form a pad. Hard rolling is best avoided, as it tends to lessen that sponginess which is so desirable a quality. If the paste has been applied in about the right quantity, the square foot of flong, the paper of which weighed about 580 grains, will, when wet and fresh, weigh about 1,400 grains, about 820 grains of this being paste; in this state it is too wet and too soft for convenient use, but if exposed to the air until something like 300 grains of water have evaporated—that is to say, until the square foot weighs about 1,100 grains—its consistency will be right for working. These weights are given principally in order that persons working from directions may be able to prepare a sample which shall have a convenient consistency, after which the remembrance of this sample should be a sufficient guide.

It is desirable to prepare the flong in the first instance with excess of moisture, and to allow this to evaporate spontaneously, as during this process of evaporation the paper swells and takes a plasticity and sponginess which is difficult to obtain in any other way.

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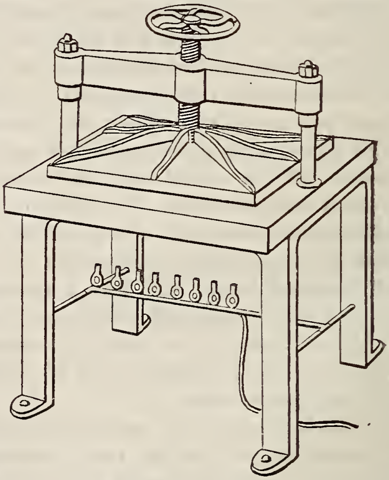
* The carbolic acid should be the tolerably pure white crystalline kind, usually sold in 1 lb. bottles, not the very crude, oily, and brown product used for pouring into drains.

Moreover, the manipulation of making the flong is easier and more satisfactory when a soft paste, containing a full proportion of water, is used. If, however, one has occasion to prepare a piece of flong for immediate use, the best way is to employ as little paste as practicable. Quite apart from the question of the amount of moisture present, it is undesirable to make use of freshly prepared flong, as it is never so homogeneous as that which has been kept for some days. It may be kept in a varnished tin tray of the right size, a stout plate of zinc being laid on the top. Generally speaking, it is best to lay the sheets of flong face to face, as the backs are likely to have been soiled with paste, and paste should be kept from the face. Flong prepared with the above-mentioned paste will keep any length of time without decomposition or mildewing, but it may become partially or completely dry. This may be remedied by one or more dippings in water, with a full allowance of time for its absorption. When flong has completely dried it is rather a trouble to get it once more in good working condition, the best way being to dip it in cold water, pile it in the storing tray, and keep this latter in a warm place, repeating the operations if necessary. Dry flong is an article of commerce, but it is more trouble to get it into good working condition than it is to start with the plain sheets of paper. It is often recommended to use two thicknesses of tissue paper on the face of the flong, and to interpose tissue between the several sheets of blotting paper, but these courses are open to objection, and, as far as my experiments go, have no balancing advantage. Two thicknesses of tissue on the face, with paste between, offer no greater security against paste reaching the type than does one thickness of tissue, and, moreover, for ease and rapidity of application, it is desirable to make the paste as fluid as practicable, and also to so work as not to involve the extra care and labour consumed in applying very thin layers of paste, and it is obvious that the larger the proportion of thin paper entering into the composition of the flong, so much thinner must be the layers of paste in order to obtain flong containing the same proportions of paste and paper. It takes much longer to spread a very thin layer than a moderately thick layer of paste.

Ease and quickness in working is generally on the side of moulding small forms rather than large, so that, when work is sent in assemblages of many pages, it is often desirable to re-impose, so as to bring down the dimensions to demy folio or thereabout; but when large pages of close matter, such as newspaper pages, are concerned, the stereotyper has no option but to mould the forms as received. When several pages are imposed together for moulding, it is sufficient to allow a pica (1-6th of an inch) between them, unless the edges are to be bevelled; in which case quite twice as much space will be required to allow for the saw cut and two bevels. The type-high clumps, as before stated, surround the whole.

Sometimes the stereotyper will have to clean the forme himself, from the carelessness of the printer who sends it to him, and in this case it should be scrubbed over with a solution of the cheapest quality of caustic soda in water (one part of soda to about eight of water), well rinsed and dried. Here, then, is the forme, clean, dry, oiled, warm, and resting on a planed slab of iron, or "beating surface," heated from underneath, the heating being in this case by gas,* although in a factory it is often more convenient to use steam. The hand is now lightly passed over the face to detect any letter which may stand high, and the planer is brought into use if necessary.† All is now ready for the moulding. I take a piece of the flong, dust its surface over with powdered French chalk, taking care to wipe off all excess, then lay it

FIG. 2.



THE DRYING PRESS.

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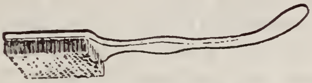
* The beating surface may be, and often is, an extension of the bed of the drying press (Fig. 2).

† The planer of the printer is a slab of hard wood, which is placed on the forme, and then struck with a mallet.

face downwards on the forme, and now comes the operation of beating.

The brush used for beating may vary in shape or weight, according to the habit of the workman, but the bristles must be good and closely packed, and the operation of beating is so similar to that of driving in a nail, that any person who is able to strike his nail every time in such a way that it shall be sent forwards and without any tendency sideways, will probably make a satisfactory mould the first time; while one in whose hand the hammer sways round uncertainly and uncontrolledly, hitting the nail at all sorts of angles, and perhaps even bending it, will not be very successful in making a paper mould from the type. In such a case it is perhaps better to educate the mind to the conditions necessary for successful hammering, by watchfully and painstakingly learning to drive drapers' pins up to the head in deal, than to waste flong and spoil type.

FIG. 3.



THE BEATING BRUSH.

The face of the brush must fall flat on the back of the flong, very little side-driving being sufficient to shift the flong, and spoil the sharpness of the mould; and a good plan is to first beat a line right across the page, and then to extend this first towards one end of the page and then towards the other. A damp cloth is sometimes laid over the flong in beating, but if the brown paper is tough and nervy the cloth is not needed, and much time is saved by not using it—far more than is equivalent to the difference in price between good and bad paper. Moreover, when the cloth is used it becomes difficult to give such local treatment as is necessary on parts where words or rules stand almost by themselves, or where there may be a mass of small type closely set, to say nothing of the special treatment required where engravings are included in the forme. As a rough guide to the extent to which the beating is to be continued, it may be stated that with flong of the right degree of softness the divisions between the words set in long primer or brevier should show distinctly on the back of the flong. If the flong is very soft, the beating must not be continued until these divisions are so distinct as with normal flong, and if the flong is very hard one will only obtain sufficient relief by making the divisions show very clearly.

The progress of the beating may always be seen by steadying the mould with one hand and turning back one corner, and the flong should always be so soft that this can be done without straining or stretching the part turned over. All this work of moulding by beating takes, as you may see, very much less time to do than to describe. Where there are extensive whites in the forme the mould will be arched downwards, and some support is needed in such places, or the arched parts would crush down by the weight of metal in the casting-box, and much metal would have to be cut away from the plate. The usual way is to paste the back of the flong, and to lay in the deep parts a few pieces of paste-board or of old mould, after which a second sheet of brown paper is pasted and laid over all. A very gentle beating is now given to the mould, care being taken not to beat this last paper down into the hollows, as the main use of this sheet is to string or tie the domes and hollows formed in the main part of the flong.

Another way—more employed in newspaper offices—is to fill in the hollows with whiting, or dry plaster of Paris may be used; the pasted sheet of brown paper being laid over as before.

The impression is now sharpened up by planing. The printer's planer—which is a slab of hard wood—is placed on the mould and struck several times with a mallet. This should be repeated several times, moving the planer between-times, and care must be taken not to shift or strain the mould sideways. Two or three thicknesses of blanket, or still better, enough blotting paper to make up about half an inch in thickness, being placed over the mould, the forme and mould are pinched up in the drying press (Fig. 2).

A few words more about the beating brush. If the face is not level, or should become unlevel by use, it may be burned flat by contact with a plate of iron heated to a dull redness, and by the same means the edge and corners farthest from the handle may be very slightly sloped off, this making it more easy to give local treatment to any special part of the mould. Workmen who have skill and confidence in the use of the brush may strike tolerably hard, and they often find it a convenience to load the brush by fastening a plate of lead to the back. Some of the Continental workmen, instead of using a brush, prefer to use a wooden blank provided with a handle and covered with several thicknesses of soft cloth or "moleskin." Then, again, a rolling machine, or a vertical press, is occasionally used in making the mould, but the press and rolling machine are of little use except in the case of tolerably solid and uniform formes, such as the pages of a newspaper. The rolling machine for moulding consists merely of a moving bed with an adjustable cylinder over it, bed and cylinder being geared together. The machine, however, is seldom used without the brush being used as an adjunct. Sometimes the press or machine is used to set the flong firmly in position on the type, the brush being used for finishing, and sometimes the brush is used first, and the machine is employed to sharpen up the impression; to do what the planer does in the process of making a mould by hand.

A sufficient drying of the mould may be effected in as short a time as three or four minutes, in which case the heat is urged almost to the softening point of the type, or the heat may be more moderate, so that the drying takes as much as half an hour. It may, however, be taken that in the case of ordinary commercial stereotyping some water is invariably left in the mould; many hours baking at a temperature of 200° Centigrade being necessary for the removal of the last traces of moisture. So that, when the best possible results are required, it is desirable (as I shall point out farther on) to considerably extend the time allowed for drying.

In ordinary cases—the work not being subject to the extreme need of haste which exists in the case of newspaper stereotyping—the forme will remain in the drying press for ten or fifteen minutes, during which time the blanket (or covering of blotting paper, as the case may be) may have been changed two or three times, or if this is not done, the press should be undone, and the covering turned over to allow the more ready escape of moisture. All this time the bed of the press may be conveniently heated to a temperature from 100° to 130° Centigrade; the former being about the degree of heat obtained it the bed forms the top of a a steam chest fed with waste or "exhaust" steam, but if "live" steam of about 30 lbs. pressure is used, the temperature will be something like 130°.

Now let us return to our forme and mould. The mould leaves the forme at once. When any adhesion occurs, something is wrong with the work, and this must be obviated in future,[*] but a slight tendency to adhere can generally be combatted by repeatedly lifting the edges of the mould as far as is possible without bending or straining the mould, and then letting it spring back; at the same time slightly loosening the quoins and beating the back of the mould with the brush will assist. In the case of persistent sticking, the only alternative is to heat the forme once more and repeatedly moisten the back of the mould with water. In this case the mould will be spoiled.

The mould, as it comes off the forme, is dry to the touch, but ordinarily not dry enough to give a good cast, and before drying it further it is convenient to trim the edges to the outsides of the gutters left by the clumps, and paste[†] on to one end a flap of brown paper long enough to project two inches or so out of the casting-box, and, at the same time, to to allow a head of metal of not less than six inches.

The mould may now be laid on a hot surface to further dry, or, better still, it may be baked in a steam or gas-oven, heated to about the same temperature as the moulding press; but in any case it should be kept flat by placing over it a piece of heavy but small-meshed wire net,[‡] and if necessary a weight is put upon this. The wire net should be in contact with the tissue paper side or face of the mould, as slight indentation on this side will do no harm, whereas any indentation on the back of the mould will show on the face of the cast; and when several moulds are piled in the oven for baking, they should be laid back to back and face to face, with a piece of sheet metal (say stout tinplate) between the backs, and one of the wire-net sheets between the faces.

The baking, or second drying, being at an end, we come to the casting, and before this is done it is a very common practice to brush some finely powdered French chalk into the mould, and then to dust out the excess by turning the mould face downwards, and gently beating the back with a flat slice of cane. This is quite unnecessary if the mould is very dry; but by the use of French chalk the effect of any trace of moisture remaining in the mould is minimised, and, moreover, the cast separates from the mould more easily—a matter of some importance when it is wished to make several casts in the same mould.

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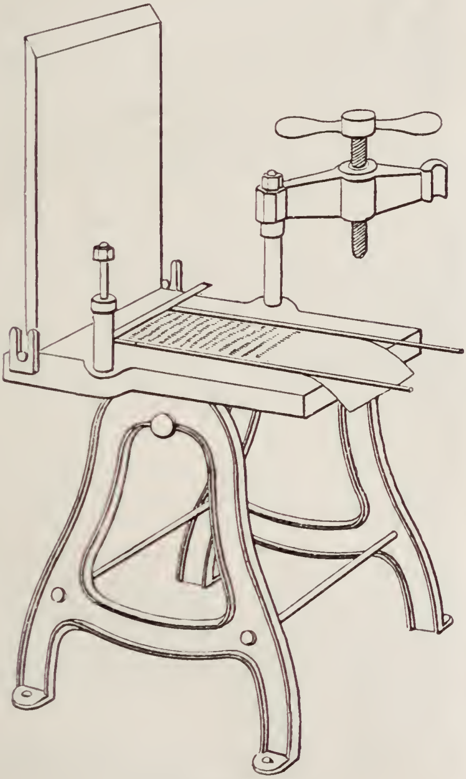
[*] Tissue paper not impervious; excess of paste under tissue paper, thus breaking up tissue; tissue broken in beating, from too hard blows or extreme softness of flong; mould too deep, so as to fit over the shanks of the types, or even penetrating between them; paste on face of the flong, from careless making or piling; imperfect oiling of forme, or unsuitable oil; alkali or other foreign matter on type.

[†] For this purpose a more adhesive paste is required than that used for making the flong. Stiff rye flour paste is best.

[‡] A suitable wire net is made with iron wire of No. 16 I.W.G. (·064 inch diameter), and six meshes to the linear inch, and can be had from firms that furnish millers' plant. The ordinary wire gauze or net sold at the hardware shops, having six meshes to the inch, is made of much thinner wire, and is not much use for our present purpose, as it has not sufficient rigidity to keep its shape as a slab or plate.

All is now ready for laying the mould in the casting-box, the casting-box having been warmed by a gas jet underneath, or I might have warmed it by casting a few blanks in it. The mould is laid face upwards on the horizontal slab of the casting-box (Fig. 4), the brown paper flap hanging a little over the lip of the box. The pica-high gauges are laid along the gutters formed by the clumps, the top leaf of the box is closed down and clamped by the screw, and the casting-box is swung on its axis, so as to bring the lips to the top.

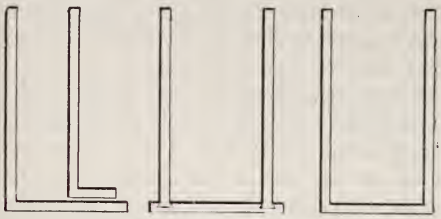
Fig. 4.



The Casting-box.

When stock sizes have to be stereotyped it is convenient to use set gauges, like Figs. 6 or 7, but in other cases it is usual to employ adjustable gauges, such as Fig. 5.

Fig. 5. Fig. 6. Fig. 7.

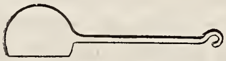


Stereotype Gauges.

When the mould is charged with type-metal, it is necessary, in order to obtain a good cast, that the whole of the metal inside should remain fluid until the mould is completely filled with metal, as if any part solidifies before the mould is full, the cast is sure to show curved streaks where the cast has solidified, and the fresh metal has not run up so closely as to make a sound cast. This is most noticeable at the back of the cast, where the casting-box exercises the most sudden cooling action on the metal, and the object of heating the casting-box is to diminish the tendency to this sort of thing. Heating the casting-box is generally insufficient in itself, when the cast is large, unless the heat is raised to nearly the melting point of the metal—an obviously inconvenient course. It is very much more convenient and satisfactory to warm the box only slightly (say to about 100° Centigrade), and to cover the face with a non-conducting coating, a coating which may be extremely thin, in fact, it is sufficient to sponge the iron plate over with a very thin wash of jewellers' rouge (finely divided ferric oxide, or, practically, much the same thing as finely divided iron rust) and water, a film of the oxide so thin as to be scarcely noticeable serving to retard the solidification of the metal during the short time required to fill the mould. Although a thin wash of jewellers' rouge is the best coating material to employ when very delicate castings of type metal are to be made in metal moulds (as, for example, in casting the thinnest "leads"), a thicker and coarser mixture, made by stirring a $\frac{1}{4}$ lb. of red ochre into half a pint of water, is often used; this being applied with a brush. London stereotypers, however, more usually lay a sheet of thin cardboard over the back plate, or a sheet of thin paper will serve, the thin paper being quite as effectual as the card in preventing the chilling of the metal, but stereotypers generally prefer the card, as lasting longer and being easier to handle. The card, however, is liable to blister, and so cause inequalities in the thickness of the plates. In this connection I may mention that, in the absence of a metal casting-box, excellent work may be done by using two slabs of dry wood, held together by screw clamps.

All is now ready for the casting of the stereotype. In this pot is some metal ready melted, and soon I shall have something to say as to the composition of the metal. To ascertain whether the temperature of the metal is about right, a strip of card or of old mould is immersed in it for a few seconds. If the card becomes of a medium brown the heat is right (about 320° to 330° Centigrade), while if it chars and blackens the temperature is too high. Should it, on the other hand, merely become yellowish or light brown, more heat must be applied; when the metal is too hot it can be rapidly brought down by stirring in some cold metal. It is important that, when poured, the surface of the metal should be clean and free from scum or oxide, as this might lodge in the cavities of the mould and render the cast unsound; and the most convenient way of cleaning the surface is to throw into the pot some powdered resin, which melts and so far agglomerates the oxide that it can readily be removed by skimming with a perforated iron spoon. Sufficient metal is now taken out of the pot by an iron ladle—one with a flat pouring-side (Fig. 8) is often used—and the metal is poured steadily, but not so quickly as to cause splashing, into the mould. Under ordinary circcumstanes it makes but little difference whether the stream is poured against the back plate of the casting-box or against the face of the mould, although the former is the most usual course, and some persons make a point of drawing the ladle along the lips of the mould during the operation of casting.

Fig. 8.



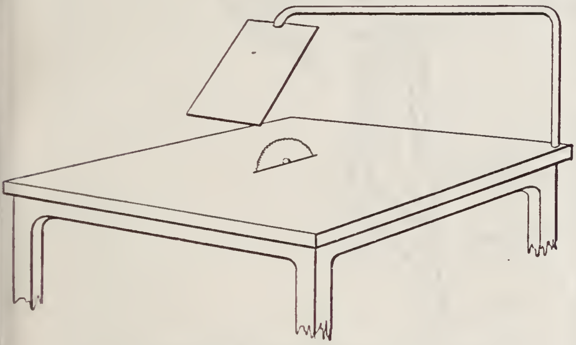
Flat-sided Ladle.

The metal used for stereotyping is much the same as ordinary type metal, only, as a rule, the stereotyper is content with an alloy tending too much towards softness, while of late years type founders have been moving in the direction of harder and harder metal. An alloy well suited for ordinary work contains 20 per cent. of antimony, the remainder being lead; or lead 4 parts, antimony 1 part. For preparing this alloy, a very safe lead to use is the soft lead which has formed the linings of tea-chests, or if commercial pig lead is used, a soft sample should be selected, and this may be sufficiently judged of by scratching the surface with the finger nail. Hard pigs often contain traces of zinc; this metal, which is especially bad in stereotyping alloys, being used in some of the desilverising processes, and the last traces are not always removed. When, however, the hardness of the pig lead is known to be due to antimony, copper, or tin, it may be used quite safely; in fact, the hard lead then becomes more desirable than soft lead. The lead and antimony being put together into the iron melting pot, sufficient heat is applied to melt the former, when the antimony gradually dissolves in the melted lead, forming an alloy which fuses at about 300° Centigrade. Lead melts at something like 330° Centigrade, while antimony fuses at 450° Centigrade, or a low red heat; the stereotype metal following the general rule that alloys melt at considerably lower temperatures than the mean melting points of their constituents. Sometimes stereotypers reduce the proportion of antimony so that the alloy only contains 10 per cent. of the metal, but in this case the alloy is noticeably soft, and wears badly in printing. A very superior stereotype metal, which is not only harder but more fusible than the above-mentioned, can be made by melting together three parts of lead, one of antimony, and one of tin. Old mixed type generally makes an excellent stereotype metal, and will often bear the addition of nearly half its weight of lead. Type metals, like so many alloys, are harder when the cooling has been very rapid than when it has been comparatively slow, and casts obtained, in a given alloy, by the paper process, are consequently softer than those by the striking process of Carez and Didot (Lecture I., p. 818).

The most positively objectionable impurity likely to find its way into the stereotyping metal is zinc, this metal making the alloy flow badly, and the face of the cast rough and patchy, doubtless by its tendency to separate from the other metals. It is, therefore, important to keep watch against its introduction into the stereotype foundry, and in melting up old type or scraps, any portions which remain unmelted, and float on the surface after the bulk is fused, should be skimmed off, as these are likely to contain the lighter and less fusible zinc. The larger the proportion of lead in the stereotype metal so much greater is the evil effect of the zinc. Zinc in lead or in type metal may be removed by calcining at a low red heat, the zinc oxidising with the first portions of the lead; but the same treatment also removes the antimony, or at any rate a considerable proportion of it. The tendency of antimony to oxidise is so much greater than that of lead, that stereotype metal used many times becomes softer from the loss of antimony. A little arsenic—say 1 or 2 per cent.—increases the fluidity and hardness of a stereotyping metal.

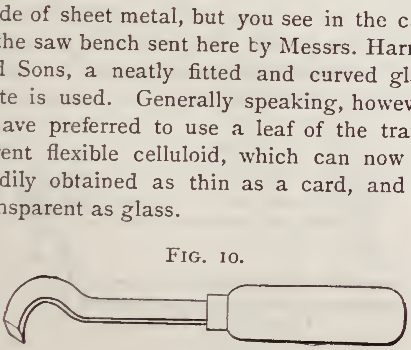
We now take the cast out of the box, and the usual thing is to trim it, or cut it up into pages with a circular saw, and as the cuttings are carried round by the saw, and thrown upwards and forwards by the ascending side, it is usual to fix a screen (as shown in Fig. 9), to prevent them going into the eyes of the operator. The screen is ordinarily made of sheet metal, but you see in the case of the saw bench sent here by Messrs. Harrild and Sons, a neatly fitted and curved glass plate is used. Generally speaking, however, I have preferred to use a leaf of the transparent flexible celluloid, which can now be readily obtained as thin as a card, and as transparent as glass.

Fig. 9.



Circular Saw with Celluloid Screen.

Fig. 10.

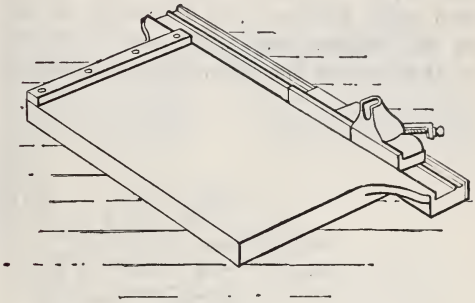


The Zinc Hook.

Instead of a circular saw, the tool known as a zinc hook (Fig. 10) may be used for dividing the plate. A metal straight-edge is used as a guide, and the cutting edge of the zinc hook is drawn along it a sufficient number of times to plough a groove half through the plate, when it becomes easy to break it.

For trimming the edges a hand plane is ordinarily used in conjunction with a shooting board, the ordinary wooden shooting board and jack-plane of the joiner answering the purpose very well. The cut (Fig. 11) represents an iron shooting board and iron plane specially made for stereotypers' use, a second plane being provided for bevelling. When the trimming planes are driven by power, the arrangement is generally substantially similar, the plane moving to and fro on a guide, while the plate to be trimmed is fed up against it, although sometimes a revolving cutter is used instead of a plane.

Fig. 11.

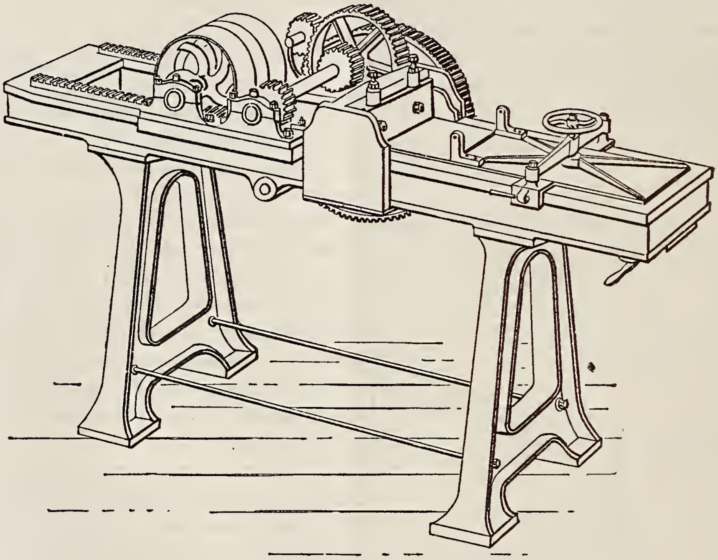


Iron Shooting Board and Plane.

Thin stereotypes, cast pica-high for mounting on blocks, ought not to require planing at the back, provided that reasonable attention is devoted to matters which influence their thickness and truth, such as the flatness of the slabs of the casting-box, the accuracy and right placing of the gauges, the keeping of the mould flat while drying, and the proper condition of the cardboard covering the back slab of the casting-box. It is easy to cast plates so true as to require no planing, indeed so true that the arrangement ordinarily used for planing, or rather scraping, the backs of thin stereotypes, would make them worse, not better. The arrangement is a kind of drawbench in which the plate is slowly forced under a stout knife placed almost vertically, and one form of it is represented by Fig. 12 (p. 838).

On referring to the diagram it will be seen that the travelling part is one with the two racks, while the double gearing and the arrangement for reversing by shifting the strap from the middle pulley—which is idle—to the right or left, according as one wants backward or forward motion, will be obvious to anyone who has given attention to machinery. The slow heavy cut, with a cutter at right angles to the plate, is essentially wrong, and tends to drag the plate out of shape, and, unless care is taken, will sometimes lift it from the bed of the machine. A machine tool for cutting stereotype metal will not work efficiently at a much less speed than twelve feet per second between it and the metal. In ordinary cases the cut is clean and easy with such a speed and an angle of 60° on the approaching side, and 15° is a good angle for the cutting edge, leaving an angle of relief of 15°. When a cutting tool rapidly removes small shavings of stereotype metal—as in the case of a circular saw or rotary cutter—there is a tendency for the clean particles of metal to weld together, and also for some of them to weld upon the clean surface of the work, thus making it rough, but a minute film of thin mineral lubricating oil prevents the tendency to welding, and it is generally sufficient to allow a brush charged with the oil to very lightly play against the cutter or the work, according to circumstances. The free use of oil on stereotypes is objectionable for obvious reasons. For heavy work water containing a little soap is more efficient, but it must be used freely. The above remarks as to the relation of stereotype metal to cutting tools apply more especially to the ordinary and rather soft alloy. It is a matter of surprise to me that a planing machine with a revolving cutter, like that used for thicknessing floor boards, is not always used for the backs of stereotypes when planing is required.

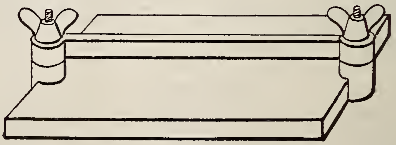
FIG 12.



DRAW BENCH FOR SCRAPING THE BACK OF THE PLATE.

In most cases—at any rate for jobbing work—the stereotype plates are brought up to type height by being nailed or screwed down on mahogany boards, these being, roughly speaking, three-quarters of an inch high; and, from the printer's point of view, it is very desirable that the thickness of the whole should exactly equal the height of the type, a matter which may very well be gauged by a sort of bridge (Fig. 13), under which the mounted stereotype can be just passed if it is the right height. Wood blocks expand when exposed to damp, and contract when they dry, and consequently they vary from time to time; so printers, when using wood-mounted stereotypes, would save time by passing them one at a time, and face downwards, under such a bridge set to type height. The low places can then be read by

FIG. 13.



GAUGE FOR HEIGHT.

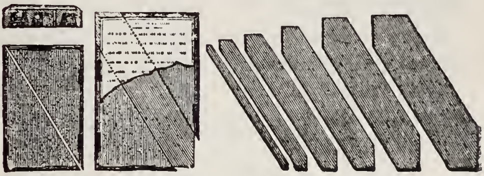
brought up with paper patches in far less time than when made up in the chase. As a matter of fact, stereotypers very seldom send out the blocks too high, as the printer finds it much easier to pack up than to plane off.

Printing from stereotypes becomes much more easy and certain if, instead of being mounted upon a material which, like wood, varies in thickness with difference in the degree of dryness, the stereotypes are either cast type high in the first instance, or are mounted upon some firm foundation not subject to considerable variations of thickness.

Casting the plates type high is a common practice for ephemeral work, as in that case the plates can be melted as soon as done with; but it is the usual practice not to cast the plate quite solid, a number of hollow spaces at the bottom, generally arched or domed, serving to lighten the plate. Any person with elementary notions of handicraft can devise for himself ready means of making cores for placing in the casting-box so as to produce the required cavities, and several ingenious forms of adjustable core are now on the table, among which may be specially mentioned that of Harrild and Son, in which a set of core-bars of graduated sizes enables one to readily cast type-high blocks to any required width. For very small blocks it is more convenient to cast solid, and if reasonable care is taken, the blocks may be cast so accurately to type height, that planing at the back becomes quite unnecessary, and the sides may readily be squared up with the hand plane (Fig. 11), or sometimes it is more convenient to cast small metal mounting blocks, and to solder the thin stereotypes upon these.

Metal mounting-blocks, upon which bevel-edged stereotype plates are held by catches placed round the edges, are on the market in various forms, much cleverness being sometimes noticeable in the devices for enabling the printer to build up any required size of mounting-block out of stock sizes, and several such arrangements are on the table before you. In the case of an ingenious device by Mr. Harvey Dalziel, the loose clips are avoided, and by dividing the mounting block diagonally, variations in size are very readily provided for by the insertion of suitable distance pieces. Fig. 14 illustrates the arrangement. The small diagram at the west side is a sectional view showing the clips, which are one with the blocks, and it also shows the coring of the blocks, while the diagram under it shows a pair of twin blocks in plan. Next we have the same adapted for a larger plate by the insertion of one of the various distance pieces, a series of which is shown on the outer side of the group. Fine adjustments can be made by inserting an ordinary lead, and it is obvious that these adjustments can be made to take effect either across or along the page, or may be apportioned between the two.

Fig. 14.

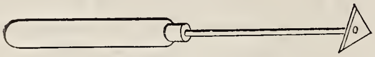


Dalziel's Stereo-Blocks.

A very firm and satisfactory blocking up of the stereo.plate is a method due to Brightley. A few short pieces of wire are soldered to the back of the plate, and it is now laid on its face and surrounded with a type-high border. A mixture of calcareous cement and water is now filled in level with the top of the border, and a flat plate, slightly oiled, is laid over and weighted. Brightley used Roman cement, but in the present day Portland cement is more convenient. This method is unsuitable when the plates are wanted for immediate use, as in ordinary cases the mould should not be removed for about twelve hours, and two days should elapse before the mounted stereotypes are used for printing.

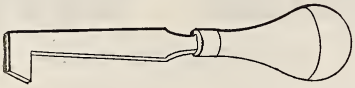
It very often happens that the stereotype requires some work done upon its face, such as cutting away the parts corresponding to large white surfaces, raising low parts, or "sinks," or soldering in letters or electrotypes. For chipping away extended whites, a very convenient tool is the ordinary carpenter's gouge, driven by a rather light mallet, an assortment of four or five gouges, the narrowest about three sixteenths of an inch across, being ample. When chipping away the metal with gouge and mallet, it is desirable to place the stereotype on a planed iron surface, provided with a transverse bar against which it can rest, the iron shooting board (Fig. 11) being convenient for this purpose. For working in narrow places, and close up to the type face, a "firmer" chisel of suitable width may be used, or a scraper shaped like Fig. 15 (p. 840), and one angle of the scraper may advantageously be ground on the edge of the grindstone, so as to shape it into a chisel-like tongue about a sixteenth of an inch wide, or a special tool, like Fig. 16, may be used for scraping between the lines. Sometimes a routing-out machine is used, in which a conical dome-shaped revolving cutter, provided with universal movements, is brought down on the plate, but in ordinary cases there is little or no saving of time by the use of such a machine. When there is a "sink" on the face of the stereotype—this being generally the result of an arching of the mould[*]—it may be brought up by laying the plate face down on a planed iron surface (a sheet of paper being interposed if this is thought necessary), and hammering on the back with a broad and round-faced hammer, such as that used by shoemakers for beating out leather; a little paper packing being then pasted on the back to support the hollow. In beating down the "sink," care must be taken to strike in the middle of the place rather than at the edges, and to strike the fewest blows that will do the work, otherwise the plate may be distorted so much as to render it useless. In the case of the thick curved stereotypes used for newspaper work on rotary machines, the machine minder will often bring up a low line[†] by driving a chisel obliquely into the metal above it and below it.

FIG. 15.



TRIANGULAR SCRAPER.

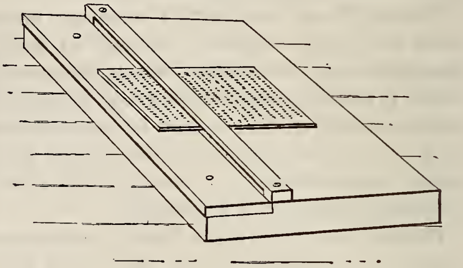
FIG. 16.



PARALLEL-ENDED SCRAPER.

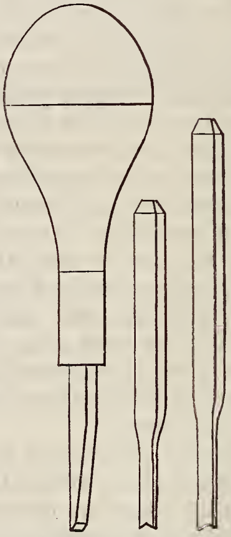
Cutting out a false letter and soldering in a type requires some care and watchfulness, but it is very easily done. The stereotype is clamped face upwards on the punching-out slab (Fig. 17), and with the line containing the false letter immediately in front of the bridge. The adjustable part of the bed, shown at the left of the diagram, being now set so as to leave a gap exactly under the line, the chisel (Fig. 18) is used to make an indentation round the letter, at any rate on those sides where access can be had, the chisel being placed with the unbevelled side next the letter to be removed, and being held vertically. A punch like one of those shown in Fig. 18, and of the right size for the letter to be removed, is now held firmly atop of the letter, and is driven through the plate by a hammer. Any metal driven beyond the plane of the back may now be cut off with a sharp chisel, and if any indentation of the face round about the hole is visible it can be dealt with as recommended in

FIG. 17.



PUNCHING-OUT SLAB.

FIG. 18.



TOOLS FOR REMOVING FALSE LETTERS.

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[*] May arise from a scrap of metal or other foreign body under the flong, penetration of liquid metal through a hole in the flong, or the joint of the paper flap, from distortions of the mould during drying, or by careless clamping up in the casting-box.

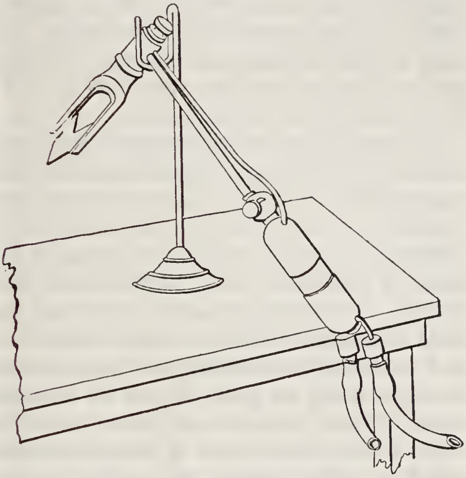
[†] The standing lines in newspapers and periodicals are often low to paper.

the case of a "sink" (p. 840). The hole is now trimmed, by means of a rectangular file,* to the bare size of the type to be inserted, and the type, after having been scraped clean on the sides, is inserted from the back. The face of the letter having been adjusted to its exact position and level, the stereotype is laid face downwards on the punching-out slab, no paper being interposed between them, a little powdered resin is dusted on, and with a rather fine-pointed soldering bit a trace of solder is applied at two opposite points of the join. The shank of the type is then nipped or broken off and the place is filed or scraped level. Sometimes a skilled workman will put a patch of solder over a false letter, and out of this engrave the required character, but such a method of working is more usually adopted when a dot or the tail of a letter is broken off and must be replaced.

The soldering is very easy if a few points are attended to. The copper bit being heated to a heat a little under redness, is rapidly cleaned about the point with a file, and quickly dipped into an acid solution of chloride of zinc,† and then rubbed on a stick of soft solder which itself has been moistened with the same solution, it thus becomes well amalgamated with the solder or is "tinned," to use the expression of the workshop. To keep the soldering bit in a good condition, its tip may be rapidly dipped in the acid chloride of zinc solution after each heating, and being then charged with solder it is ready for use on the stereotype plate, and if the part to be soldered is sprinkled over with powdered resin, this will be sufficient protection, and the small drop of solder carried up on the tip of the bit will unite and flow readily. The acid chloride of zinc solution should not be applied to the type metal, as it rather corrodes it than protects it.

When much soldering has to be done, as for example, if electrotypes of wood-cuts are to be soldered into stereotype plates, a soldering bit, heated by a small gas blowpipe, is a great convenience and saving of time, and the device represented in Fig. 19 is a specially convenient one for the stereotyper, this sketch, like some others I have put before you, being taken from Monet's very useful work, *Procédés de Reproductions Graphiques**, and the instrument itself can easily be constructed by any all-round mechanic. The tubes leading gas and air respectively (the air being conveniently supplied by a foot bellows) are shown first passing through a wooden handle and thence into the cylindrical head of the apparatus, where is fitted a small Herapath's blowpipe, the flame of which plays upon the small copper bit held, as shown, by two lugs extending from the cylindrical head. A cock is placed on the gas-pipe just over the handle, and where it can be operated by the thumb of the right-hand, while the crutch shown on the figure forms a convenient support for the blowpipe when not in use.

FIG. 19.



SOLDERING BIT HEATED BY GAS BLOWPIPE.

Although very little care and attention on the part of the workman will enable him to use ordinary soft solder of the tinman without fear of melting the adjacent parts of the plate, there are cases where it may be desirable to use a more fusible solder, in which case Wood's cadmium solder may be employed. It melts at a temperature considerably under that of ordinary solder, works nearly as easily, and is quite as strong. It is prepared by melting together cadmium 2 parts, tin 4 parts, lead 2 parts.

An alloy of bismuth 2 parts, tin 1 part, and lead 1 part, forms a solder easy to use, moderately strong, and melting below the boiling point of water.[*] When figures have to be altered several times, this solder is convenient to use, as those first soldered in can be readily removed by immersing the plate in boiling water or heating it till, when touched with a wet finger, one can just feel steam formed, then giving the figure a slight tap to drive it out.

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* Files of rectangular section down to a square file about 1-50th of an inch across can be obtained at the watchmakers' material shops of Clerkenwell or Soho.

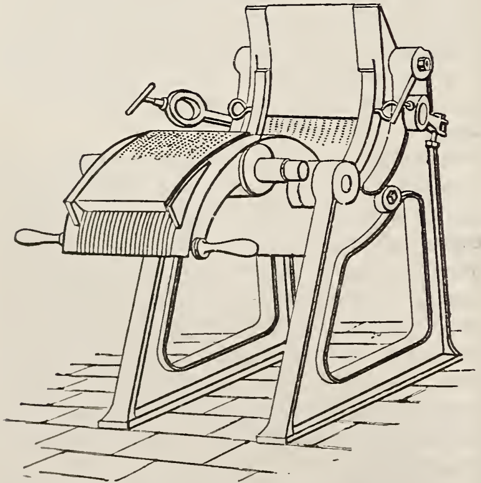
† Commercial hydrochloric acid saturated with zinc, and when poured off from the excess of metal, is mixed with one-fourth of its bulk of hydrochloric acid.

* Procédés de Reproductions Graphiques, appliquées a l'imprimerie, par A. L. Monet. Super royal octavo, 444 pages, 103 cuts in text, and 13 plates. Price 10 francs. Paris, 1888: Administration du "Bulletin de l'Imprimerie," 7, Rue Suger.

In stereotyping for newspaper work everything is carefully studied to attain speed, especially in the case of the evening papers, and it becomes possible to mould a page and cast a plate in about ten minutes. In such cases the plates are cast curved, so as to fit the cylinder of the machine used.

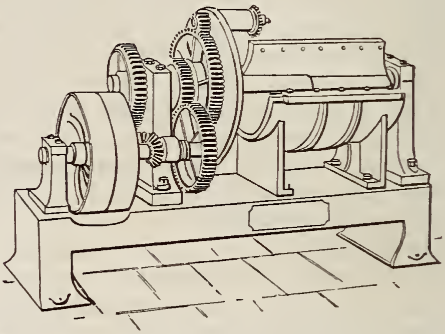
Two workmen beat the flong to make the mould; a rolling press being often used to finish the moulding. There is generally very little packing of the whites to be done, so it suffices to sprinkle a little whiting upon the back of the mould, and scrape it into the hollows with a straight edge, after which the final thickness of brown paper is pasted on, and the forme is run under a hot press to dry, the heat being as great as can be ventured upon without damage to the type. In two or three minutes the mould is removed, finally dried on a hot surface for another similar period, is dusted with French chalk, and is then placed in a curved casting-box (Fig. 20), the metal being poured in at the side of the page, while in the older pattern of curved casting-box it was poured in at the top. The metal is poured from a large three-handled ladle like that used in iron foundries. The trimming of the cast is generally done while it is warm, and by slow-moving tools, as chips rapidly removed from the hot metal are more likely to weld on the freshly-cut surface than is the case with cold metal. Therefore, the ordinary machine for boring the inside of the cast, and in which a single knife is made to revolve slowly and take one heavy cut (Fig. 21), is less unsuitable than might at first sight be supposed. But in this case, if a revolving cutter were used, and were fed with slightly soapy water by a series of conduits in the cutter-bar, it is quite likely some economy of time would be effected. Soap, like oil, soils the surface of the type metal sufficiently to prevent welding.

FIG. 20.



CASTING-BOX FOR CURVED PLATES.

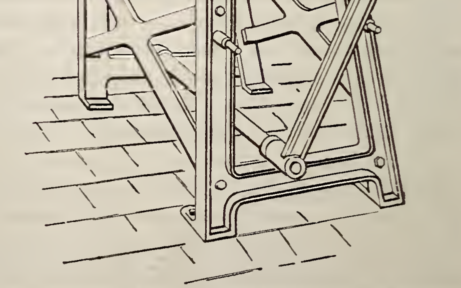
FIG. 21.



MACHINE FOR BORING THE INSIDE OF THE CURVED PLATE.

A common form of apparatus for trimming and bevelling the edges of the curved stereotypes is that shown in Fig. 22, the plate

FIG. 22.



TRIMMING MACHINE FOR CURVED PLATES.

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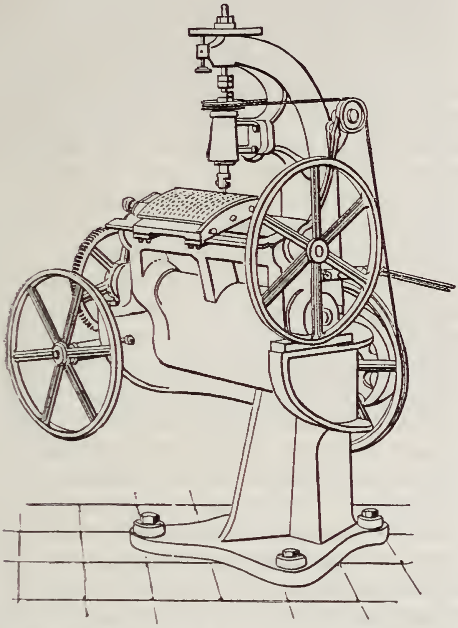
[*] Wood's fusible metal, referred to farther on, forms a still more fusible solder.

being clamped down on a suitable saddle, and trimmed by adjustable knives, the holders of which are moved backwards and forwards by hand. Another trimming machine is represented by Fig. 23. In this case we have a revolving cutter and the plate is fixed upon a saddle which traverses and rotates by hand gearing.

FIG. 23.



TRIMMING MACHINE WITH REVOLVING CUTTER.

Occasionally plates intended for printing on rotary machines are cast flat, and afterwards bent to the required curve, and there are two methods of doing this. In one case the plate, previously warmed, is forced down into a curved die by a sort of platten formed of stiff leaves of spring steel, but when the same machine is intended to bend to any curve, a bed piece, similarly formed of plates of spring steel, must be laid over the die. In the other case the stereotype is laid between steel plates thin enough to spring, and is rolled several times through a set of three rollers, one of which is adjustable so as to give the required set.

In either case, it is necessary to place paper or a blanket between the face of the stereotype and the steel plate, and the results of the bending are seldom quite satisfactory, unless the plate to be bent is fairly solid, as in the case of an ordinary newspaper page, any extended whites interfering with the regularity of the bending. In the case of electrotypes, which are ordinarily backed up with a softer metal, the bending is easier, and electrotypes are often bent that they may be soldered into curved plates for illustrated newspaper work.

The work of the newspaper stereotyper is very seriously interfered with if any wood-mounted blocks are inserted in the forme he has to mould, the heat passing so much more slowly through wood than through metal as to make it almost a matter of certainty that the mould will be less dry when over such blocks; this being not only calculated to give a rough face to the lines, but also to lead to a distortion of the face of the mould in the second drying. This evil is especially apparent in the case of the zinc process blocks, which are made very thin, and are consequently mounted on an extra thick block of wood. The separate moulding of the blocks and casting type high, or the mounting of them upon solid metal bases, is so easy that there is scarcely an excuse for being so unfair to the workman as to send pages containing wood-mounted blocks when a stereotype is required in a minimum of time.

Probably the interfering influence of the wood mount is largely responsible for the tradition that the paper process is unsuited for the reproduction of the finest engraved work, but personally I am quite convinced that if all or most reasonable precautions* are taken to ensure the very best results, stereotypes can be made by the paper process, which are equal in fineness of surface and definition to the best electrotypes, and are superior in durability to many of the very thin shells of copper on a base of very soft metal, which pass now-a-days. In illustration of this I have on the table reproductions of fine engraved work, some of which I have done myself and others have been done for me by London stereotypers, a request for additional care having in almost every case had the desired result. Just before the lecture Mr. Dallas brought me this very finely stippled photo relief block—which you will admit is a crucial test object, and with it he brought me this paper-process stereotype made from it by Messrs. Sharrow and Anderson, and if you look at these carefully they will bear out what I have said. The paper process is, however, very ill adapted for moulding direct from wood cuts, owing to the action of the heat and moisture on the wood, and it is seldom employed for this purpose unless in the case of very small blocks, or when time necessitates it. The stereotype by the paper process is, when at its best, smooth, brilliant, and lustrous on the face, where the metal takes the impress of the compressed and hardened matrix, while the low parts, which are cast in contact with the spongy part of the mould, are always rough and often unsound in the sense of being permeated by holes and faults. The depths are nicely rounded and the square shoulders of the type-shanks show not at all, or only faintly.

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* Such as clean and evenly but slightly oiled original; well united, thoroughly seasoned, and rather dry flong; drying thoroughly in the press with occasional tightening up; long baking of the mould; non-use of French chalk; a suitable hard metal—say the tin alloy given on p. 836—and this at as high a temperature as the mould will bear; and a considerable "head" and margin of metal in casting, the margin being of the full thickness of the gauges.

I have spoken of the circumstance that in all ordinary stereotyping work some moisture remains in the mould, and I want to show you that it is possible to make a fairly sharp cast in a mould which is quite wet. This forme is warm, and I beat a piece of flong on it to make a mould, and I put the mould in the warm casting-box. You see all is now quite wet, and signs of vapour are visible at the mouth of the box. On pouring in Wood's fusible metal,* which melts considerably under the boiling point of water—say between 60° and 70° Centigrade—a very fairly good cast is obtained, the heat not having been sufficient to convert the water into steam. This experiment is interesting, not only as showing a possible means of making a stereotype in a shorter period than the usual time—although the high price of bismuth tends to put it outside practical work—but also as illustrating a point of some importance, that, in the case of a mould not very thoroughly dried, the best result is obtained with the metal at as low a temperature as practicable, whereas in the case of a mould baked for a long time, the hotter the metal is, the better the result, provided it just stops short of burning the paper; so it is possible to have failures either from the metal being too hot or too cold. The use of French chalk on the face of the mould tends to minimise the mischief resulting from traces of moisture in the mould, but as it invariably makes the face of the cast a little rough, it should only be used when needed. Another use of French chalk is when numerous casts are required from the same mould, as it tends to prevent adhesion between the cast and the mould. When a large number of casts are required from one mould, other precautions to be observed are to use a well-cemented and ripened flong which is not too soft, to avoid making the mould too deep, and to beat with numerous gentle blows, rather than with a smaller number of heavy blows, as this tends to give a mould in which the depths are nicely rounded off, and do not follow the nearly vertical sides of the type face. Again, patches of old mould, or pieces of thin sheet metal may be laid in the more considerable depths of the form, so as to support the flong where subject to the greatest strain. Some stereotypers do this in the case of most ordinary work; while those who have a difficulty in beating the flong without shifting it do the same in the case of all very open formes.

The question of damage to type during the process of stereotyping is one of some importance, and it mainly steps in when a high temperature is employed for drying. If the forme is very tightly locked up in the chase it may, in expanding and softening under the heat, become elongated, while on the other hand it may become shortened by the pressure of the drying-press. These two circumstances tend to make a newspaper fount become of unequal height, and the fount is rendered useless. In reference to this subject, Messrs. Caslon and Co. have sent me one of their circulars, dated April, 1880, from which I may quote the following:—

"A remarkable instance of the dire results of severe locking has lately come under our notice. A daily newspaper was supplied with founts, in the manufacture of which special pains had been taken to produce an amalgam of the toughest and hardest consistency—and with remarkable success. Within a few weeks our attention was called to certain appearances in the types which led to a close inspection and consultation. The matter was approached by founder, compositor, stereotyper, and engineer, with a sincere desire to ascertain the cause of the serious phenomena, and the evidence led conclusively to but one result—viz., unnecessary pressure in locking. The tremendous force exerted on the columns had been such that the back of some of the types bore, in clearly defined ridges, the marks of the nick on the type against which it stood. In fact, the metal was crushed into the space formed by the nick, and the feet of other types bore like impressions of the bevel of a lead or rule they stood next to. The body of the type was also found to be smaller, when tested by gauge, and, worse than all, they had become longer, or, to use a founder's expression, higher to paper, by as much as a twelve-to-pica lead!

"There is no remedy for this evil after the mischief is once done; but there is a valuable practical lesson to be learned which all overseers of newspaper offices will do well to enforce. Let the formes be locked with only a moderate force, sufficient to secure safe lifting. With the enormous power at the operator's command, only a slight turn of the wrench produces enough pressure on the type to secure this end—which may be verified by experiment—and then we strongly advocate loosening the formes as soon as they are placed on the hot stereotyping bed, so as to allow for expansion. When possible, lifting the formes at all should be dispensed with: they should be imposed and then slid along on a continuous bed or imposing surface right on to the moulding bed, so as to avoid all possibility of accident. With such convenience at command there would be no necessity at all for excessively powerful locking apparatus, and the ordinary wooden quoin and side-stick would be found sufficient. .... We strongly advocate the insertion of wood furniture—say about two-line pica reglet—between the long side-stick and the type; for, in case of undue expansion of the type in the process of moulding for stereotyping, the wood would give way before the metal type, and the latter would therefore be preserved."

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* One part of cadmium, two parts of tin, four parts of lead, and seven parts of bismuth.

Since the date of the circular quoted, the typefounders have done much in the way of using harder metal for their types, but the precautions mentioned are still needed.

It is sometimes desirable to mould work, in case of a future demand; but this is not done so often as it might, because the printer does not care to take the trouble of sending the formes to the stereotyper. Now I want to show you how easy and inexpensive a thing it would be for any printer to mould his formes immediately they come from the machine, and to keep the moulds in case of future need. Here are the formes of a 16-page weekly publication, and a set of light metal frames fit in the gutters so as to bring these up to the level of the face of the type. These pieces of flong—each corresponding to a page, with the necessary margin—are rather over-dry than moist, and with them I mould a page at a time, and not many seconds are required for moulding each page, while as each mould is made it is lifted off and set aside. The formes have not even been washed, as the remaining ink does no harm in this case, and the moulds being removed at once, there would be but little risk of adhesion, even if there were not a trace of ink on the type. The damp moulds are now laid between quires of rough paper, this being sufficient to keep them flat during the time of drying, which may be several days. When dry they are stored away in bundles. In casting from one of these moulds a few pieces of old mould are pasted into the hollows at the back, and the brown paper flap is pasted as usual on that edge which is to be the top, but the extra thickness of brown paper at the back is dispensed with. In some newspaper offices it is the practice to take the moulds off some of the earlier pages while wet and dry them separately. When the mould is removed wet there is a contraction of about a one hundred and thirtieth linear.

More or less successful attempts have been made in the direction of moulding the type in a dry and spongy millboard and casting at once—these methods being called instantaneous stereotyping processes—much the same sort of thing as I showed you at the end of my previous lecture—but nothing of this sort has come into general use. The pressure required for a newspaper page would be enormous, and the results hitherto have not been quite satisfactory.

The paper process of stereotyping lends itself very well to the production of plates for printing in several colours, whether for typographic or block work. A series of plates cast in immediate succession, in the same well dried mould, corresponding very exactly; and it is better to cut away from each plate those parts not wanted than to attempt to block them out in the mould, as this latter course may easily lead to distortion. In cutting away the waste metal from the plates, care must be taken not to strain or distort them, and for such a purpose the routing-out tool alluded to on p. 840 is very useful.

The mention of cutting away plates for printing in several colours recalls a use made of stereotypes early in this century by Charles Babbage. He would obtain a number of casts of a block showing a complex machine, and by cutting them away he would produce a separate block showing each important organ of the machine, and these would be printed alongside the complete sketch.

Miscellaneous.

◆

SCIENCE SCHOLARSHIPS.

Papers have been received from the Secretary of her Majesty's Commissioners for the Exhibition of 1851 respecting the establishment of science scholarships, from which the following particulars are taken:—

"In their seventh report to the Crown, presented in July, 1889, the Commissioners for the Exhibition of 1851 announced their intention of appropriating an annual sum of not less than £5,000 a year to the establishment of scholarships, to enable the most promising students in provincial colleges of science to complete their studies either in those colleges or in the larger institutions of the metropolis; care being taken that these scholarships should be a supplement to, and not in competition with, scholarships already existing through either public action or private endowment.

"The decision to restrict the scheme of scholarships to provincial colleges was due to the feeling of the Commissioners that the provinces, which took so large a part in supporting the Great Exhibition of 1851, had a just claim to receive as direct a benefit from the funds derived from that Exhibition as is afforded to the institutions on the Commissioners' estate at South Kensington, which although unquestionably of national importance, confer a more immediate advantage on the metropolis.

"To assist them in preparing a scheme for the distribution and regulation of the scholarships, the Commissioners obtained the services of a committee of eminent men of science, namely, Professor Garnett, Professor Huxley, Professor Norman Lockyer, Sir Henry Roscoe, and Sir William Thomson. To these were added two Commissioners, Mr. Mundella and Sir Lyon Playfair, the latter of whom acted as Chairman of the Committee.

"On 18th June last, this Committee presented the accompanying report on the scope and objects of the scholarships, and it has been adopted by the Commissioners.

"The Committee then considered the manner in which the scholarships should be distributed. On this point they were bound by the restriction of the present scheme to students in provincial institutions, in which term, however, they suggested that colonial universities might be comprised. They thought it unnecessary to include in the scheme the Universities of Oxford, Cambridge, and Dublin, in view of the large endowment of those bodies. The Committee decided upon the allotment of an annual series of 17 scholarships, and the institutions named in the list will be invited to nominate scholars subject to the conditions laid down in the Report of the Commitee, and provided that they possess scholars worthy of the purposes explained in it.

"The present allotment is to be considered experimental and temporary, and the selection now made of institutions to which nominations are offered will be subject to modification in the future, having regard not only to the manner in which the nominations are exercised, but also to the claims of other universities and colleges which may from time to time be brought under the consideration of the Commissioners."

The Committee, in the report referred to above, propose:—

"1. That the scholarships shall be of £150 a year in value, and shall be tenable for two years, but in rare instances may be extended to three years by special resolution of the Commissioners. The continuation, each year after the first, shall depend upon the work done in the previous year being satisfactory to the Scientific Committee, which it is suggested shall be appointed by the Commissioners.

"2. That the scholarships shall be limited to those branches of science (such as physics, mechanics, and chemistry), the extension of which is specially important for our national industries.

"3. That the Commissioners shall from time to time select a certain number of provincial and colonial colleges in which special attention is given to scientific education, and give to each the power of nominating a student of not less than three years' standing to a scholarship, on the condition that he indicates high promise of capacity for advancing science or its applications.

"4. That the Commissioners shall appoint a committee of advice, who will consider and report upon the reasons for which the nominations are made by the respective colleges, and the Commissioners will appoint to the scholarships upon the report of their committee.

"5. That the scholarships when awarded shall be tenable in any university either at home or abroad, or in some other institution to be approved of by the Commissioners. The holder of a scholarship must give an undertaking that he will wholly devote himself to the object of the scholarship, and that he will not hold any position of emolument during its continuance."

CULTIVATION OF COCOA IN CUBA.

The French Consul at Santiago, in a report to his Government, says that the cultivation of cocoa is closely connected in Cuba with that of coffee, and is carried on at the same time and on the same properties. In fact every coffee planter, if the nature of the soil permits him to do so, sows between the rows of young plants cocoa berries, which will produce trees that will continue to bear crops when the coffee plants have ceased to produce. It is impossible to discover the precise date at which the cultivation of cocoa was introduced into the island, but as this plant was cultivated in Mexico and in New Grenada before the Conquest, it cannot long have remained unknown to the Spanish colonists in Cuba, who kept up constant communication with the possessions of Spain on the American continent. It was not, however, until about 1830 that several planters made an effort to introduce cocoa into Cuba, and at this time plantations of a certain importance were formed at Figueroa and elsewhere. Unfortunately for many years the cultivation of the cocoa remained unprofitable, in consequence of the small demand and the low selling price. The price slowly rose however, the number of cocoa plantations increased, and by 1860 every coffee plantation in Cuba combined the cultivation of the cocoa, if the nature of the soil permitted it. The cocoa-tree lives longer than the coffee plant, but it is much slower in producing. It takes in fact five or six years before the newly planted cocoa begins to bear fruit; it is at its full bearing at the end of the year, and begins to decline at the end of fifteen, but without ceasing to bear; on some old estates there exist cocoa-trees of upwards of fifty years of age, which still produce. The cocoa is usually planted in the spring, by preference directly after rain; an interval of from ten to twelve feet is usually left between the plants. The kinds which are most used are those of *Caracas*, *Guayaquil*, and the *Creole* variety, which latter is said to come from Trinidad. The Caracas and Guayaquil varieties bear the finest fruit, but they are not so hardy, and do not bear so well in Cuba as the Creole variety. The Caracas, however, fetches the best price. The crop is gathered from the month of October to the month of August. During this period the trees are covered with blossom, and little bunches of ripe and half-ripe pods. The crop may therefore be gathered day by day, but as it is difficult to obtain the labourers necessary for the work, the owners generally prefer to harvest monthly or fortnightly. To prevent fraud as much as possible, the labourers are paid by piece-work, and receive wages calculated upon the number of measures of fruit which they pick. There is no harm done by leaving the pods on the bushes for one, two, or even four weeks, except in the spring, when, if possible, they should be picked at shorter intervals. The cultivation of cocoa, like that of coffee, is undertaken with the aid of colonists, who are hired by the day. The day is calculated from 6 a.m. to 4 p.m., for which time a man is paid about 2s. 6d. if food is not included, and about sixpence less if it is. The colonists are farmers to whom the proprietor of a cocoa plantation has let a piece of ground, with the right to cultivate fruit or vegetables, but with the obligation of yielding the planter half or two-thirds of the cocoa gathered on the same piece of ground. Cocoa is weeded in the same] way as coffee, but as the cocoa-tree sometimes grows to a height of fifteen or twenty feet, it is not so much troubled by coarse weeds as the coffee is. The spread of weeds is, moreover, checked in cocoa plantations by the continual fall of leaves, which soon cover the ground. The cocoa is pruned in the same way as the coffee-tree, with a view to prevent each plant growing too high and mingling its branches with those of its neighbours. It is necessary always to take great care to remove the suckers which are continually being thrown up from the foot of the tree. As soon as the pods are ripe, they are pricked and broken on the spot. The berries, which are full of a curious syrup, are measured and piled up in heaps, covered with leaves. These heaps are allowed to ferment for two or three days, the fermentation being regulated every morning by a rearrangement of the heaps. This process softens the bitterness of the berry, destroys the gum which surrounds it, and enables the cocoa to dry more rapidly. Moreover, the colour of the berry depends on the proper conduct of the fermentation. Cocoa, like coffee, is then spread for two or three days on a sort of platform made of cemented stones, called a *secadero*, there to be exposed to the sun and dried. As soon as the cocoa is thoroughly dry, it is rubbed, cleaned of all the detritus which has gathered upon it, placed into bags, each containing about 105 lbs. of cocoa, and sent on the backs of mules to the market at Santiago. The conditions of transport are the same as in the case of coffee. Each mule carries two sacks, or 210 lbs. of cocoa, and travels ten leagues every day. Each group of twenty mules is led by a *capataz* and two watchmen, and travels by night to avoid the heat. The conductor, or *arriero*, is responsible for the arrival of the convoy, which is paid at the rate of fivepence a mile, and per mule, or from five shillings to five shillings and sixpence per day's journey of twelve leagues. Part of the cocoa grown in Cuba is consumed in the island, but the berries of the finest quality are sent abroad, and generally to Barcelona. France imports no Cuban cocoa whatever. The Cuban cocoa is, says the French Consul, exceedingly fine in quality, and it appears strange that there is no market for it in France. The price of cocoa in Cuba varies from twelve to sixteen piastres the quintal, and sometimes, but rarely, rises to eighteen piastres. The Caracas berries are sold one piastre dearer than the other varieties. The Consul says it would be difficult to foretell the future of cocoa cultivation in Cuba. Many cocoa plantations were destroyed during the civil war, but cocoa has suffered on the whole much less than coffee from the effects. In many of the largest plantations in the island the cultivation of coffee is now entirely abandoned, and the cocoa plants only are depended upon for a return. Many planters moreover prefer cocoa growing, because for small capitalists it is an industry which requires much less outlay than coffee.

RUSSIAN TOBACCO TRADE.

It appears, from a report which has recently been addressed to the Foreign Minister at Constantinople by Chédid Effendi, Turkish Consul at Taganrog, that, after cereals, the most important branch of Russian production is tobacco, which ranks second as a source of the natural wealth of the country. It is particularly cultivated in the Crimea, in Bessarabia, the Caucasus, at Batoum, and in the territory of the Don. Statistical returns show that the area under tobacco cultivation in Russia fell off very considerably in 1889, and that the product was below the average consumption. According to the official statements, these results must be attributed to two causes, the first being that a large number of producers gave up tobacco growing on account of the fall in prices and the stock in hand, which amounted on the 1st January, 1890, to over 2,885,000 pouds (poud is equivalent to 36 lbs. avoirdupois); the second cause was the unfavourable weather and the want of rain, which prevented the regular development of the plant to such an extent that a deciatine of land (deciatine = 2·7 acres), which ordinarily produces from 80 to 100 pouds, only yielded half this quantity in 1889. The soil of Russia being of an extraordinary fertility, it is not necessary to use any natural or chemical manures. The planters are nearly all Ottoman subjects, natives of the vilayet of Trebizond—they number over 3,000 in the Caucasus and in the Don districts. The finest Russian tobacco is produced in the Crimea, the Caucasus and Batoum come next, and the Bessarabian and Don tobacco rank third. Before the rapid development of tobacco culture in Russia, manufacturers were obliged to have resource to Turkey and Greece, and it was only in 1877, or 1878, that the Russian Government, with a view to augmenting the revenue, imposed an exorbitant duty on foreign tobacco. Up to this period the customs duties were payable in paper money, but since that date they have been payable in gold. Foreign tobaccos, which formerly paid only 4·40 roubles per poud customs duty, now pay 15·40 gold roubles, which is more than the price of the finest Russian tobacco. This enormous difference in the duties seriously affected the trade, and the Tanganroy market, which formerly received from 20,000 to 30,000 pouds annually, now only takes about 2,000 pouds. Odessa is the only place which continues to receive any considerable quantity. Formerly, Turkish tobaccos were imported in Russia, from Salonica, Trebizond, Samsoun, and Smyrna, as well as from other localities in Asia Minor, while at the present day the importation is limited to the tobaccos of Smyrna and Macedonia. All tobaccos, foreign and native, can only be placed on sale after having paid a consumption duty, which is assessed at 36 roubles a poud for the finest quality, 19·20 roubles for the second, and 4·80 for the third. Cigarettes of the first quality pay 2 roubles a thousand, those of the second 90 copecks. The manufacture of tobacco is only permitted to be engaged in by persons well known as holding good positions and having the necessary resources for carrying it on. There are at Taganrog two factories, the proprietors of which pay to the Russian Treasury nearly a hundred thousand roubles annually in the shape of duties and taxes. These two establishments employ over 200 workpeople of both sexes, whose wages vary between 20 copecks and 2 roubles a day for each person, according to the age and capacity. These two establishments turned out in 1889 six thousand pouds of tobacco and ten millions of cigarettes. Of this quantity two thousand pouds of tobacco and three million cigarettes were consumed in the district of Taganrog, the remainder being sent into the interior of the country and particularly to Moscow, whence it is sent abroad. The paper used in the manufacture of cigarettes is generally obtained from Finland and to some extent from a privileged factory at Odessa. The exportation of Russian tobacco by the port of Taganrog has hitherto been insignificant.

General Notes.

RAMIE AS FOOD FOR SILKWORMS.—The current number of the *Kew Gardens Bulletin* contains a communication respecting the use of the ramie or rhea plant (*Boehmeria nivea*) as a food for silkworms. The information was received at the Foreign-office from Mr. A. de G. de Fonblanque, H.B.M.'s Consul at New Orleans. A lady in Columbia, S.C., who reared silkworms, being unable to obtain the leaves of the mulberry or Osage orange, made use of the leaves of the rhea plant, which were eaten ravenously be the worms. When sent to Philadelphia, the cocoons were stated to be larger, and the silk finer than was the case with those of worms fed on mulberry and Osage orange leaves. It is added:—"If further experiments should prove that Ramie leaves can be depended upon for silkworms' food, then a great impetus will be given to the production of this valuable article in the south, while it will add to the profits of those who raise that plant for its fibre."

AUSTRIAN MINING PRODUCTION.—The French Ambassador at Vienna, in a communication to his Government, says that according to a recent official return the products of the mines in Austria, in 1889, represented a total value of 58,939,809 florins, an increase of 4,976,028 florins, or 9·22 per cent. over the preceding year. The number of persons employed in the mining industry was 113,058. The product of the working of the gold mines in Austria, in 1889, amounted to 13,162 kilogrammes of pure gold, representing a value of 17,673 florins. These mines are exclusively worked by private individuals and companies. The silver mines yielded in all 35,435,350 kilogrammes of pure metal, of a total value of 3,157,153 florins. Of this amount, 98·92 per cent. was obtained in the mines worked by the State. The number of workmen employed in the gold mines only amounted to 85, while those in the silver mines exceeded 5,500.

CORRECTION.—Page 827, col. 1, line 43; col. 2, line 2, *for* bisulphate of magnesia, *read* bisulphite of magnesia.

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Proceedings of the Society.

CANTOR LECTURES.

STEREOTYPING.

By Thomas Bolas, F.C.S., F.I.C.

Lecture III.—Delivered March 3rd, 1890.

Plaster Process, Electrotypes, Casts in Steel, Iron, Brass, and other Refractory Metals, Celluloid, Rubber, and Gelatinous Composition, Auto-stereotyping, Miscellaneous Processes.

It is useless for me to attempt giving anything like such full working details of the numerous processes which have to be considered in this lecture as was the case when I spoke of the paper-mould process, as each would probably occupy as much time as was taken up last week with the paper process alone, and, even by trespassing on your patience as much as was then the case, some ten or fifteen lectures would be needed.

The invention of the plaster-mould process was spoken of in the first lecture, and in spite of the comparative slowness with which work is turned out, and the cumbrous nature of the appliances required, the plaster process survives, principally for casting from formes of music type. In this case it is specially adapted for the work, as so many of the music characters hang over the body or shank of the type, and these overhanging sorts would be very liable to injury in moulding by the paper process also in the drying-press: while the plaster mould has the advantage that imperfect joins in the lines of the music staff can be made good by carefully drawing a piece of metal rule along the lines in the mould.

When a forme is set with the view of being stereotyped by the plaster process, quadrats and spaces as high as the shanks of the letters are often used, and, for the convenience of stereotyping, music founts are ordinarily furnished with high spaces and quadrats.

Narrow clumps are generally placed so as only just to surround the forme, and outside these we have the ordinary low furniture. The first thing is to rub a paste of plaster of Paris and water well into the interstices of the forme, this being done with the hand, and as the plaster sets the excess is brushed away with a stiffish brush, so as to leave the face of the type clear of plaster, the depths of the forme partly filled in, and the vertical sides of these depths sloped off with banks of plaster.

It is desirable to allow this "filling-in" to become dry before further treatment, and warmth may be employed to expedite the drying, after which the face of the type is finally cleaned by the brush, and any fragments of plaster which clog the faces of the letters must be picked out. The forme, being now clean and dry, is thoroughly oiled, enough oil being used to saturate the surface of the filling-in plaster, and although the type should be well oiled, the hollows on the face of such letters as *o* or *e*, should not be left full of oil. The low-priced thin mineral lubricating oil recommended in the case of the paper process is inconveniently thin, so it is better to use such an oil as cotton-seed oil, or rape-seed (colza) oil.

Some strips of thin sheet metal are now laid on the furniture, outside the narrow clumps,* and an iron frame about three-quarters of an inch deep is laid over, so as to enclose the forme with its clumps, when some plaster of Paris, mixed with water to the consistency of thick cream, is poured over the type, after which a brush is worked with an up and down motion in the plaster covering, so as to chase away air-bubbles, but this brush should not be drawn out of the plaster till the dabbing is finished, or fresh bubbles would be created. The frame is now filled with the mixed plaster, and as it begins to set, the top is scraped off level with a straight-edge. All the plaster should be of the same mixing, as if a stiffer plaster is used to fill up, there will probably be distortion in drying. Rather low-priced plaster is often to be preferred for this purpose than the very finest quality, which commands its high price mainly on account of its whiteness, freedom from dark specks, and the fineness with which it is ground. It is of the utmost importance that the plaster used should have been freshly roasted, and at such a heat as to set quickly and firmly. The stereotyper can easily judge of these points for himself. Extremely fine grinding is no advantage, as the surface obtained is no better than with moderately fine grinding, while flatter and better casts are obtained in the latter case. As a rule, the plaster should be obtained direct from the maker, who will usually supply the smallest quantities if sent for; and generally the grade sold in London as "fine" is more suitable than "superfine" or "double-superfine." In mixing the plaster, a quantity of water is taken in a basin, and powdered plaster is added in a stream till it is judged that enough has been added. Before proceeding to mix with a spoon, it is well to see that the water has penetrated to the top of the blunt cone of the plaster, which at this stage will stand above the water level. In this case it is easy to mix the plaster without forming many air-bubbles, which would not be the case if the water were added to the plaster. Mixing-basin, brush, and spoon should be thoroughly washed immediately after use.

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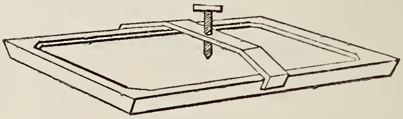
* Clumps are not essential in working the plaster process, but are desirable for several reasons.

In ten minutes or a quarter of an hour the plaster mould should be set, and the cast can be removed, and for this purpose a tool like a miniature two-pronged crowbar is used, the opposite sides of the frame being gently prised up in succesion to the minutest appreciable extent, after which the frame, with its cast, can be lifted off; but any unwatchful application of force in this case will spoil the mould. The moulding-frame is always bevelled so that the plaster cast can readily be removed from the top, and the cast is now baked at a heat of from 200° to 210° Centigrade for about two hours, care being taken to so place it in the oven that the air can circulate as freely all round it as practicable—for example, on its side, or, better still, on a flat shelf formed of such heavy wire-netting as was previously referred to (p. 834, Lecture II).

Here is a mould already baked, and the essential point in casting from such a mould as this is to retain the melted metal in contact with it for a considerable time, say ten or twelve minutes, but it is quite easy to obtain a cast without the heavy and expensive plant ordinarily used. Over this gas-burner is a rectangular iron dish, and it is now heated to about the melting-point of type-metal. In it I place the plaster mould face downwards, the border of the mould having been cut away at two points so that metal can flow freely under it; and over the mould is fixed a bent iron plate, which will prevent it rising nearer to the top of the dish than an inch, when metal is poured in. Having now filled the iron dish with melted type-metal so that the plaster mould has floated up against the stop, I will leave the gas burning for about ten minutes, and if it is then extinguished we shall have a good cast as soon as all is cold.

In actual practice, the rim of the plaster cast is cut away at two or three points, and it is placed face downwards into an iron box, called a dipping-pan (Fig. 24), while under it is a loosely-fitting iron plate. The cover of the dipping-pan is held in position by the iron strap and screw shown in the diagram, but this cover is cut away at the corners so that the metal can freely flow in. This dipping-pan is lowered into a pot of melted type-metal and kept there for ten or fifteen minutes, after which it is lifted out and cooled. The plaster cast floats up against the lid of the dipping-pan, while the floating plate rests against the rim of the plaster mould, thus gauging the thickness of the cast. Little need be said about the trimming and finishing of the cast except that, as the cast is not of an accurately gauged thickness, and, moreover, as the floating plate is rough—as there would obviously be no advantage in surfacing or planing it—it becomes essential to trim or plane the back of the plate, and this is generally done by a special surfacing lathe. Although plaster expands at the moment of setting, it afterwards contracts in drying, and a plaster stereotype is therefore smaller than the original by about 1-80th linear.

FIG. 24.



THE DIPPING-PAN.

Gypsum, the mineral which, when gently roasted, gives plaster of Paris, may be regarded as a compound of sulphate of lime (calcium sulphate) and water in the proportions indicated by the formula—

$$CaSO_4 \, , \, 2H_2O.$$

The above formula corresponds to about 21 per cent. of water in the mineral, but when the gypsum is exposed to a heat ranging from 120° to 250° Centigrade, about three-fourths of the water represented by the above symbol is driven off, and the gypsum falls to a coarse powder, which then has approximately a composition expressed by the formula—

$$2\,CaSO_4 \,.\, H_2O.$$

This expression corresponds to about 6 per cent. of water, and if the plaster in the course of manufacture is heated above 250° Centigrade, and the retained water is reduced much below 6 per cent., the plaster will harden but slowly. In hardening, the sulphate of lime reunites with water, forming a compound which is probably identical, from a chemical point of view, with the original gypsum.

When the mould is baked at a temperature of about 200° or 210° Centigrade, the greater part of the water is driven off, and the mould retains the 6 per cent. or so which is contained in ordinary plaster, but during the long contact with the fused type metal, at a temperature of about 320° or 330°, almost the whole of the remainder is driven off, and a sound cast is not obtained until this is the case. The reason why the thick plaster cast is not baked in the first place at a temperature above the melting point of the metal, and a cast obtained by simple pouring in of metal, is the extreme friability of the completely dehydrated mould.

Messrs. Sharrow and Anderson, who work the plaster process in London, and turn out about 200 music pages a day by this method, have been good enough to send me a set of specimens showing the various stages—the forme and moulding-frame, rough cast and dipping-pan, and also a finished plate.

A modification of the plaster process exists, in which the friability of the completely dehydrated plaster mould is overcome by the expedient of making the mould of extreme thinness, and in close contact with an iron plate; indeed, the mould is so thin that the face of the cast is virtually made on the surface of the iron; the plaster in this case adhering to the iron in patches and ridges, forming reverses to the depths of the original. A woodcut consisting of a close mass of fine lines, without large patches of white, or a grained photo-tint block in which there are no considerable depths, can be easily reproduced by a method of this kind, as the mould adherent to the iron plate consists of very small and thin deposits of plaster which have not much tendency to scale off, and which can be completely dehydrated by exposure for a short time—even a few minutes—to a heat about equal to that of melted type-metal. Sometimes the iron plate is studded with small holes, tapering larger toward the back, so as to give a better hold to the plaster, but this device is especially needed when such an original as a forme of type is moulded from, and the reliefs of plaster are more considerable. A method of this kind may, in some cases, compete for rapidity with the paper process.

In working by this method, the original—after being "filled in" with plaster, if necessary, and oiled—is smeared over with a thin layer of mixed plaster, and the iron plate to be used (this may be one plate of the casting-box used for the paper process) is similarly smeared over with plaster, but, naturally, the iron must not be oiled—indeed it may be advantageously rubbed over with white of egg to promote adhesion. The two plastered surfaces being now pressed together with considerable force, ten or fifteen minutes are allowed for the plaster to set, after which all that excess of plaster which exudes from the sides is trimmed off, the mould on the iron plate is dried at about 320° Centigrade, and the cast is made by backing up the mould with another iron plate (or the other leaf of the casting-box), and pouring in metal as when operating by the paper method. A modification of this mode of working can be used in making reproductions of medals by casting in plaster moulds, two plates of iron, the register between them being insured by steady-pins, forming the framework of the mould; the mould being then made by spreading a little plaster on each iron surface, and compressing the original between them. The original must not only be slightly oiled, but must be inserted in a hole cut of the right size in a sheet of oiled paper, otherwise the two parts of the mould would not separate.

The electrotyping process is very extensively employed in making stereotypes* of engravings, or of letter-press matter containing engravings, and when the original wood is to be moulded from the electrotype, this method is perhaps the most desirable process of stereotyping, as no moisture or heat is used in moulding; and in spite of what I said about the best possible stereotype by the paper method being equal to the best electrotype, the average commercial electrotype of the present day is very much better, as regards surface and definition, than the average commercial stereotype by the paper process.

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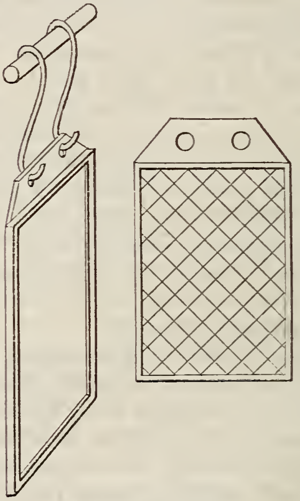
* Among the London craftsmen the words stereotype and electrotype—or rather "stereo" and "electro" are used as distinguishing terms—and the former term is so exclusively applied to the stereotype in type-metal, that to speak of an electrotype cast as a "stereotype" is regarded as a barbarism.

If an electric current is passed through a solution of copper sulphate (blue-stone or blue vitriol), so that the current passes from one copper plate immersed in the solution to another copper plate also immersed in the solution, one of these copper plates will become thicker from the deposition of copper, while the other plate becomes thinner by the dissolving away of just so much copper as was deposited upon the first. In this case, although the solution of sulphate of copper is doubtless decomposed and reformed during the action, it is there at the end; and for our present purpose we may regard the change as a mere transference of copper from one plate to the other, the deposition taking place on that copper plate connected with the zinc plate of the electric battery, and the dissolving away taking place in the case of that plate connected with the other pole of the battery, which may be a silver plate, a platinum plate, or a carbon plate. This action you can see going on before you, not only with a battery, but also with two forms of dynamo machine used as the source of the electric current; and if I replace one of those copper plates, upon which more metal is being deposited, by a wax mould of typographic matter well brushed over with black lead, the copper is deposited on this mould, and in time there will be a compact film of copper covering the mould. This film when thickened up by a layer of type metal forms the ordinary electrotype used by the printer.

In the room is a very complete set of specimens illustrating the various stages of the ordinary process of electrotyping, these having been lent by Messrs. Richardson, Koolman, and Isger; and the shortness of time at my disposal must make me content with showing you these, rather than demonstrating every stage of the process. There are also some illustrations sent by Messrs. F. Plummer and Co.

The forme from which a stereotypic cast is to be made by the electrotype process should be surrounded with type-high clumps, and be filled in with plaster of Paris, as in the case of a forme for reproduction by the ordinary plaster method; then the face of the forme should be thoroughly brushed over with powdered black lead. All is now ready for moulding in a bed of wax. It is desirable to use genuine beeswax (unbleached), and to soften it by adding to it about one-seventh of the turpentine sold as Venice turpentine; and when these materials are melted, it is usual to stir in a little (say one-thirtieth) of finely-powdered plumbago (black lead). The wax mixture having been melted in a jacketed steam pan or water bath, and well stirred, it is allowed to settle for a second or two, and a strip of paper is drawn along the surface to bring any air-bubbles to one side, when the wax mixture is ladled out into shallow pans, about one-third of an inch deep, and cast of soft type-metal, called moulding-pans (Fig. 25), these being laid out on a level slab. It is well for the pans to be very slightly warm when filled, and they should be filled so that the wax stands well up to or a little over the edges. As a rule the wax does not crack in cooling unless it has been adulterated with the so-called Japan wax, but one remedy in this case is to add a little more of the turpentine. Unless there is gross clumsiness in filling the moulding-pans, nothing more than a few isolated air bubbles will be formed, and these can be readily broken by touching with a pointed iron rod, which may well be warmed so as not to chill the wax. The wax, when set, should, like the forme, be well blackleaded with finely-powdered

Fig. 25.

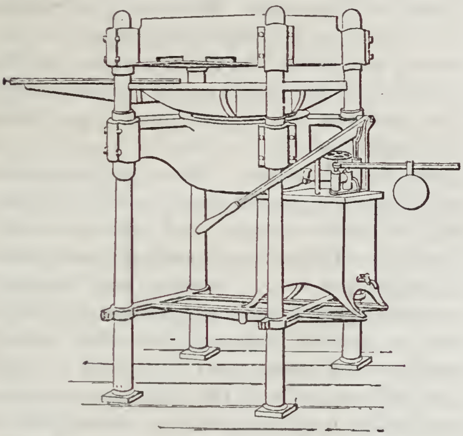


Moulding pans.

blacklead, a soft, long-haired brush being used in its application. The moulding must not take place until the wax has thoroughly cooled, as, if this were done, the internal portion, being softer, would very likely exude; but the wax plates, when once cooled, may advantageously be kept ready for use in a warm place rather than a very cold place.

For moulding from the type, a rather lightly-built hydraulic press, made something like Fig. 26, is used, the only notable features besides lightness of build being the shortness of the rise, and a slab of iron on the bed, which can be pulled out drawer-fashion. The forme being placed on the draw-slab of the press in such a position that it shall come fairly over the ram, the blackleaded slab of wax is laid over it, and sufficient pressure is applied to mould all the details. In removing the mould from the forme, the same sort of care is required as when removing the plaster mould from the type, and when removed there will always be some superfluous wax to trim off. The parts of the mould corresponding to the more extended whites will probably require building up with wax, so that the electrotype shall have sufficient depth, and perhaps the simplest way of doing this is to hold a pointed pencil of iron or copper (building iron) in the right hand, and having warmed the metal rod, a slender stick of wax is held against it, so that a slow and steady stream of melted wax flows from its point. A watchful person can soon learn to lead this stream to the required places, and can raise the wax close to the borders of cavities in the mould, without fear of filling them. Several "building irons" of assorted size should be provided, and if a minute gas jet plays on the tool, a little way from the tip, time will be saved; the gas being led through the hollow stem of the "iron" by an indiarubber pipe about one-sixteenth of an inch in diameter. For "raising" the mould between fine lines, an ordinary pen may be mounted in this way, the small gas jet playing on its back, and dips can be taken, ink fashion, from a pot of melted wax. A building pen, capable of holding more wax, and suitable for coarser work, may be made out of a piece of copper-wire cable, the wires being cut away at various points, so as to make a conical termination ending in two wires only, which form the working point, and the tool will be more lasting if each cut-off end is brazed down in its place with a minute patch of spelter or silver solder.

Fig. 26.



Hydraulic Press for Making the Wax Mould.

The wax must now be thoroughly blackleaded by beating and rubbing finely-powdered black lead on to the face of the mould, either by hand or by a machine, until every part is covered, after which the back and sides of the moulding-pan are painted over with melted wax to render the surface non-conducting, and all is ready for the depositing bath. Very much depends upon the nature of the blacklead (plumbago, graphite) employed to make the surface of the mould conducting, and the electrotyper is often so much impressed by the desire to obtain a "perfectly pure" article or something of the "very finest quality," that he pays quite extravagant prices to those who profess to supply such. Blacklead, which is a form of the element carbon, is a mineral, and is always accompanied by traces of impurities, such as iron or earthy matters, and although samples containing much earthy matter are less desirable than those containing a small proportion, the point at issue is mainly one of structure. Blacklead ranges from hard crystalline scales to almost an amorphous mass, and neither one extreme nor the other is most suitable, but the kind best for our purpose is one which in grinding will break up into very minute and *thin* scales, a quality which can be recognised by a microscope examination, but a practical test is best for the electrotyper. A moulding-pan having been filled with wax and cooled, a plate of thin sheet metal, having a slot about a quarter of an inch wide in it, is laid stencil fashion across from edge to edge, and is held firmly in position while one of the samples to be examined is brushed through the slot for a certain number of minutes. The stencil having been shifted, other samples, perhaps to the number of twenty or thirty, are similarly brushed on the slab of wax, after which it is put in the depositing bath and connected to the source of current, when the rapidity and perfection of the covering on the various strips will give nearly all the information wanted, although before finally deciding, the three or four samples which come out best should be tested on an actual mould having rather deep and narrow lines. In this case the quarter-inch test strips would be no use, and a very good way is to cut out a metal or card templet which will leave, say, a fourth of the mould uncovered for each sample. A suitable blacklead is generally made worse by platinising or gilding, and a blacklead most suitable for a soft mould is not always the most suitable for a hard mould.

Not only have many other materials than wax been used in typographic electrotyping, but gutta-percha is now very often used in France; also there are other ways of moulding. These matters I would much like to discuss at length, but time does not permit. I may, however, refer to Mr. Clay's convenient method of moulding, by which the "filling-in" of the forme with plaster is avoided. A piece of stout linen is laid on the forme, and over this a sheet of india-rubber, after which the moulding-pan is placed in position and pressure applied; in this way a general impression is obtained, and a second pressure without the linen and india-rubber sheet gives a moulding of the sharp face of the forme. The essential point is to ensure exact register in placing the mould in position the second time, a very easy matter if the chase and moulding-pan are provided with corresponding pins and holes. By using a soft wax, a mould of moderate size can be made by this method with an ordinary printing press, or a screw-press.

In the depositing bath a simple solution of sulphate of copper, nearly saturated, is all that is wanted, and although London electrotypers in many cases still use the Smee battery, a series-wound dynamo, driven by a steam-engine, is, under ordinary circumstances, a much more economical source of electricity; but the special circumstance that favours the survival of the battery is the facility it offers for depositing during the night, when it would be an additional expense to keep the engine running; but even in this case secondary batteries charged by a dynamo during the day would probably be more economical.

Here is a small Siemens' series-wound lighting dynamo (D 6), a kind of machine which would in many cases be better suited to the needs of an establishment for typographic electrotyping than are some of the specially-made depositing machines, which are primarily intended for operations in which much heavier deposits are required, and this machine, while consuming only about a quarter of a horse-power, and running quite slowly, will give a current of about 20 amperes with a tension of eight volts. It is now giving about that current, and is depositing copper over an area of something like two square feet, at the rate of about 184 grains on the square foot per hour, and you see it gives good deposit with this current of no less than 10 amperes to a square foot of surface. We might have six or eight depositing cells in series, each depositing the same amount, and giving a total deposition of from 2,000 to nearly 3,000 grains of copper per hour. In using one "series" machine by itself some precautions are necessary to prevent reversal, but when several machines are in use, one can be used to excite the field magnets of the others, an arrangement which conduces much to convenience of working, and is, moreover, suitable for the charging of secondary batteries.

When a sufficient thickness of copper (say 1-30th to 1-40th of an inch) has been deposited upon the wax mould, hot water is poured on the back of the copper electrotype (called the "shell") to disengage it from the wax mould, and the rough back of the shell is "tinned" with a coarse solder consisting of equal weights of tin and lead, such coarse solder having less tendency to run through any holes in the shell than would be the case with a solder having a full proportion of tin. This alloy is usually granulated by being poured through a gauze net into water, and it should be quickly dried, otherwise some oxidation will take place. The shell having been trimmed to the outside of the clump marks, is laid face downwards in a shallow iron pan (backing-pan), which can be heated either by being supported on the surface of a bath of melted backing-metal (generally made rather soft; lead 16 to 18 parts, antimony 1 part, a little tin—say three-fourths of a part—being added, unless the lead used is known to contain tin), or by a gas burner. If the shell tends to curl, it is easy to keep it tolerably flat by laying iron bars on the level edges left by the clumps, and the clean back of the shell is now brushed over with the acid chloride of zinc solution (*see* foot-note p. 841, Lecture II.), and sprinkled with the granulated solder, a final brush over with the solution being given if the solder does not spread to all parts immediately. The backing-pan may now be removed from the source of heat, and before the solder has time to set, melted backing-metal is poured on in a steady stream, commencing in the middle and travelling outwards as a spiral, so as to build up a thickness of at least a pica all over the shell,* the clump edges of which may be turned up so as to form a dish, unless iron bars have been placed round as before mentioned.

The "electro" generally requires some hammering upon a level iron slab to bring up "sinks" (p. 840, Lecture II.), and the levelling of the back is generally done by a special surfacing lathe, as in the case of stereotypes by the plaster process. There is often a little afterwork to be done on the face of the electrotype, this being done by a workman called a "picker," who must be deft in the use of engraving and soldering tools, and in the case of fine-cut work it is desirable to mount electrotypes on solid blocks of type-metal, and for this purpose one of the fusible solders referred to in the last lecture may be used (p. 841); the top of the block and the bottom of the "electro" being both well amalgamated with the solder, then brought into close and solid contact while sufficiently heated. A sort of cold soldering is sometimes employed, the two surfaces being separately amalgamated with mercury, and then held in close contact by a press till the excess of the mercury has diffused into the mass.†

The casting of stereotypes in brass (the material used for the earliest stereotypes on record) and in other refractory metals, has not yet become general, although the extensive present use of rotary and other machines for printing and branding directly upon wood is likely to create a demand for iron and perhaps steel stereotypes.

Iron or brass casts can be readily made in sand or loam moulds, but in moulding it is so much more convenient to mould from an ordinary stereotype than from the type forme, that I have no hesitation in very confidently recommending this course. As moulding frames, two ordinary printers' chases may be used, one having register pins fitting into corresponding holes in the other, and both being furnished with a few cross wires to support the sand; but a gap should be cut away from the top of one to form an ingate. One part of Stourbridge clay and two of Bath-brick dust forms a very good mixture, and after this has been slightly damped, well rammed, and carefully levelled into the casting-box, the pattern stereotype is oiled and is forced by a press into the soft surface. A little brick-dust being sifted on to serve as a parting material,* the second chase is placed in position and filled with the moulding mixture, after which the frames are separated, the pattern removed, and the mould is baked. For casting, the two frames may be conveniently clamped up in the ordinary stereotype casting-box (Fig. 4, p. 835), a few channels being cut for the escape of air. The mould should be well dried, but not too rapidly, or it is rather liable to lose its face by a kind of granulation or scaling, and the metal should not be so hot as to cause "sand burning." On the table are moulds and casts which I have made to illustrate this method of working, and Mr. Peter Barry has been good enough to send me some very excellent casts which he has made. Stereotypes in high steel might perhaps be made by casting in moulds of lime compressed dry, and I have obtained promising results by this method, but should such be required they could, I think, be made, even if of considerable size, by the "striking" method indicated in Lecture I. (p. 819).

I find that by using a piece of wet asbestos millboard as a material for making the mould, we can stereotype in brass or iron by a method quite comparable to the ordinary paper-mould process, and I will illustrate this to you by making a cast in brass.

When the asbestos millboard, which may be about an eighth of an inch thick, has been wetted, it is pressed against the forme by means of a screw-press (there is no need to work from a previously made stereotype in this case), removed, dried at a heat bordering on dull redness, and with a similar piece of plain asbestos millboard clamped in the usual stereotype casting-box, with a bent iron wire gauge between them; the brass is then poured in at the top. In this case there is no need to warm the casting-box, the slow conducting quality of the asbestos preventing all chilling of the metal.

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* The French electrotypers always place gauges on the clump marks when pouring on the backing-metal, and just as it is on the point of solidifying, the platen of a press is brought down on it. In this way, the need of planing the back is often obviated, and the tendency to sinks and irregularities of the face is diminished. Of course when the above course is taken, the tinned shell must be placed on an accurately-planed surface. The French method is better adapted for rather thick than thin shells.

† As a means of fastening types together to form solid stamps (stereotypes in the sense in which Didot first used the word), the mercurial method of soldering is admirable, and it is also fairly satisfactory for fixing a letter into a stereotype plate, provided that the fit is accurate.

* As the pattern is generally forced in so as to be level with the surface of the mould, a sheet of oiled paper may be laid over instead of using parting sand.

The body of a cast made in this way is rough, and generally somewhat unsound, being cast against the spongy body of the asbestos millboard, but the face, which is cast in contact with the hard and compressed portions of the mould, is sound and good.

To show you what can be done in the way of typographic brass-casting, Mr. Nettleton, of Barnsbury, has been good enough to send me samples of his cast brass type, both in the rough and finished; these, I understand, are cast in iron moulds.

The various photo-stereotype or photo-typographic methods do not come within the scope of the present lectures, but I have now the opportunity of showing you some Arabic printing types cast in matrices reproduced by photographic means from an impression taken from type of a larger size. In this case the reproduction was made for Messrs. Stephen Austin and Sons, of Hertford, by Mr. Alfred Dawson—so well known as a successful worker in photo-engraving methods, and I am told the cost was only a small fraction of what the expense would have been if punches had been cut. I also have placed upon the table reproductions which I made some years ago of some letters from a book printed by Sebastian Gryphius, of Lyons, in 1539, and alongside them are the matrices and body mould. In this instance each letter, cut out of a photo-type block, was set separately in a level plate of metal, at the required distance and a thick electrotype cast was made of the whole. This was strengthened by a backing of soft metal, and when cut up it formed the matrices.

Celluloid, as a material for stereotyping, has been proposed by Jeannin, who makes his mould by mixing the soft unfused oxide of lead known as massicot, into a stiff paste with glycerine, and if baked for about five minutes in contact with the forme, at about 120° Centigade, the mould becomes hard, and separates. The celluloid is then softened at about the same temperature, and forced into the mould.

The same kind of mould answers well for making stereotype casts in the so-called Spence's metal (sulphur slightly hardened), an excellent composition of this kind being the following:—

Sulphur	100 parts.
Finely powdered pumice stone	30 ,,
Native sulphide of antimony ..	4 ,,

It requires careful melting, as if over-heated the sulphur would pass into the viscous modification, and it should be well stirred before pouring.

The use of india-rubber stereotypes has not gone much beyond their employment as hand stamps. The mould in which the rubber is vulcanised is generally made of a mixture of plaster of Paris and French chalk, the forme being "filled-in" with soap, to insure easy separation. As only small casts are ordinarily made, it is convenient to mix the plaster and French chalk (equal parts of each answers very well) to a paste with water, and to spread this on a level surface, and to force the forme into it. At other times the bed of plaster is moulded on the type with two successive pressures, the first with a cloth covering, and the second without a cloth, these operations requiring a means of keeping register, and being similar to Mr. Clay's method of moulding in wax for electrotyping. If a large mould is required, nothing is better than M. Jeannin's composition of massicot and glycerine while simple plaster of Paris answers very well, especially if after drying it is hardened by saturation with a solution of shellac in alcohol. The mould having been obtained, is dried and warmed, and some uncured rubber, mixed (by strong rollers) with about one-tenth its weight of sulphur,* is softened by a gentle heat, and forced into the mould, after which the whole is exposed to a heat of 140° to 150° Centigrade for about half an hour, during which time the sulphur reacts chemically on the rubber, and what is called vulcanisation results, the rubber no longer becoming plastic by heat. Hot-presses for the vulcanisation of rubber stamps are now sold at a moderate price, or a simple arrangement, which I showed in this room nine years ago, may be used. It consists of a cast-iron fish kettle, upon the bottom of which is cast a slab of type-metal an inch thick. Inside the kettle is placed a small press, like a copying press in miniature. By the side of the press stands a small iron cup, containing glycerine, and in this fluid is immersed the bulb of a thermometer, the stem of which projects through a hole in the cover of the kettle. By means of a small gas stove, heat can be supplied to the apparatus, and it is easy to so adjust the gas supply, that the thermometer shall indicate a tolerably constant temperature of, say, 140° or 150° Centigrade, the slab of metal serving as an equaliser of heat.

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* Mixtures of this kind can be obtained where materials for making rubber stamps are sold.

Mr. John Leighton introduced rubber stereotypes about 26 years ago, and his firm has been good enough to send here samples illustrative of their manufacture and use, a subject which in itself might well occupy a whole lecture. At one time experiments were made as to the practicability of using rubber stereotypes on rotary printing machines, as they would easily adapt themselves to the required curves, and might be expected to save power in the working of the machines. Fatty ink soon softens and destroys rubber stereotypes, so that an ink made by dissolving an aniline colour in glycerine is generally used. These will generally fade rather rapidly on exposure to the light, but by dissolving nitrate of silver in glycerine we have an ink which does the reverse. At first it gives a colourless impression, or nearly so, but on exposure to light it gradually becomes deep brown.

Elastic stamps, which can be used with the ordinary printer's ink, can readily be made of any required hardness with a gelatinous composition similar to that used for the ordinary printer's inking rollers. The making of these is a very simple matter indeed. A piece of very thin sheet lead, such as is sold for covering damp walls—say about an eightieth of an inch thick—is slightly oiled, laid over the forme, and beaten with the moulding-brush until a satisfactory impression is obtained, after which it is laid on a level flat surface; a border is placed round it, and a melted gelatinous mixture is poured over it; any mixture, such as is used for printers' roller composition, will serve, although something rather harder will often be required. By soaking a fine hard gelatine (Coignet's silver label gelatine, for example) in water till it has absorbed about its own weight of water, and then melting it with half as much glycerine, a serviceable hard composition is obtained, but with some tendency to shrink, which can be met by adding more glycerine, and heating for some time in a flat dish over boiling water, so as to evaporate some of the water.

Under the head of auto-stereotyping I propose to deal with a few of those methods, in which lines are cut out or indented on a level surface by some sort of sketching or writing action, this writing being then used as a mould in which is cast a stereotype, from which the writing or drawing may be printed, and of late years such methods have come much into use, and have acquired considerable importance.

If one simply takes a blunt style, and, while using some considerable pressure, with this makes a sketch on a very soft paper board* or a blotting-pad, a mould is obtained which, if cast from—as in the ordinary paper process of stereotyping—yields a block that can be rapidly deepened by the engraver, and may serve very well as an extemporaneous illustration for a newspaper; and as the material for this sort of thing is always at hand in a newspaper office, it is a very convenient method to employ when only a rough sketch is required; and by a very simple expedient, the labour of cutting away the whites of such a cast may be obviated, provided there is no objection to the sketch appearing on a ruled or cross-hatched ground. Before making the sketch, a hard impression of a lined, dotted, or cross-cut block is made on the paper pad,† and the sketch is afterwards made with the style. A cast now being taken, the ruling or dotting gives sufficient support on the whites, and the sketch shows as lines on the tinted ground.

The above is essentially a process for rough or hasty work of the crudest character, and we now pass on to one of the earliest methods, and perhaps the best of all, if perfection of result is considered, namely, the glyphographic process, invented by Edward Palmer‡ about 1841. A thin coating of wax, whitened by a suitable pigment (white lead or other heavy lead compounds answer best), is spread on a blackened copper plate,§ and the sketch is made on this with a point, so as to lay bare the black copper, the dark lines thus produced showing the artist the progress of his work. Any lettering may be done with stamps or types, the wax ground being softened by a little heat if necessary. The extended whites are now raised by the building process already described in reference to the wax mould for electrotyping, the hot pen there mentioned being used for filling in between the finer lines, and during this process any false line may be covered; after which an electrotype cast is made from the wax mould. Binger, in his "Glyphographie," published at Amsterdam in 1850, gives as fine examples of work by this process as any since done. It is now very extensively employed, and it is understood to be substantially the method by which several well-known firms produce blocks. As it would be in many cases obviously inconvenient to submit the traced wax plate itself as a proof, a photograph is often sent.

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* A thick "wood middle" or pulp-board answers well.

† An assemblage of ordinary brass "rules," plain, dotted, or waved, may be used.

‡ Palmer kept a well-known philosophical instrument shop in Newgate-street, and was succeeded by Horne and Thornthwaite.

§ The clean copper can be blackened by a weak solution of silver nitrate or platinum tetra-chloride.

There are several processes roughly classed as "clay" processes, in which a mineral mixture is used on the copper plate, and a cast is made directly in stereotype metal from the tracing made on this surface, and I will illustrate to you the form of this process which I have found to work best in my own hands.

I now take a plate of copper which has been roughened by glass paper, blackened by a solution of perchloride of platinum, rubbed over with white of egg, and then flooded with a white-wash composed as follows:—Stereotype paste, as given on p. 830, Lecture II., 6 oz.; whiting, 24 oz.; water, 3 pints. Enough should be allowed to remain on the plate to form a layer 1-20th to 1-30th of an inch thick, and the plate is then set in a horizontal position to dry. A design can be readily traced with a point through the friable ground, and after the mould has been dried at about 200° Centigrade, a cast is made in the casting-box ordinarily used for the paper process. Apart from the operation of deepening the whites of the block and the making of the sketch, the whole work can be performed in ten minutes or so. The mixture used for coating the plate may serve to "raise" the whites on the mould, this preparation being put on by means of a pipette, but such a course is not to be recommended, as it involves delay in drying, and there is increased chance of the coating leaving the copper. The most essential point is the use of albumen on the roughened plate, this enabling a friable mixture to hold on sufficiently for practical purposes.

Closely analogous to the autographic stereotyping methods are those in which a machine analogous to a type-writer is used to make a matrix, letter by letter, on such a material as flong, wood, or soft dry pulp boards, and in Guillot's "Graphitype" (Lecture I., p. 819) we have the parent of all such methods. The weak point in all these processes is the difficulty of making corrections or alterations, and no printing method which does not provide for this is likely to be generally accepted; the only matrix method which gives this facility in a high degree being the matrix-setting method of Herhan (Lecture I., p. 820), which method, if operated in connection with a type-setting machine, should be quite as rapid as the type-writer methods, and it allows alterations as readily as when ordinary types are used.

In these lectures much I should liked to have talked of has been necessarily omitted.

Miscellaneous.

IMPORTS OF BACON AND PORK.

Pork, as an article of food, is theoretically banished from the tables of one half the housekeepers of our cities and large towns, but finds much favour in the form of bacon, and is equally as digestible in that form as fresh beef or mutton. A pig, for its size, is one of the most useful of animals, inasmuch as he is good from top to toe, and there is no part of him which cannot be turned to account.

The yield of the several parts of the hog depends not merely upon the weight, but upon many other things, as the breed, the health, the age, &c. For the American markets hog-sides are cut in Chicago, for the most part into what are called "short ribs" and "mess pork," and when so cut the several yield is about as follows:—

	Short Ribs. Per cent.		Mess Pork. Per cent.
Shoulder......	10	Shoulder......	10
Ham	11	Ham	11
Lard (rendered)	15	Lard (rendered)	11
Short rib	39	Mess pork	40·5
	75		76·5

In addition to the above, the following products are secured:—

Tender loin, about 1 lb. per hog.

Tongue, about 1 lb. per hog.

Lean trimmings, $1\frac{1}{2}$ lbs. per hog.

Heart, 0·25 per cent. of live weight.

Feet, 1·56 per cent. of live weight.

Cheeks, removed from bone, 0·20 per cent. of live weight.

It is held that American pork suffers more by shrinkage in cooking than the British product. American pork loses 50 per cent., while Irish pork loses only 25 or 30 per cent. This is to be ascribed to the higher proportion of fat it contains.

Besides the home production of bacon in England and Ireland, upwards of 175,000 tons were imported last year, chiefly from the United States; of hams about 49,000 tons, besides 59,700 tons of lard. Half a century ago we only required 56,000 tons of foreign bacon and hams, valued at £2,000,000; now we pay £10,500,000 sterling for our foreign pork, and more than £2,000,000 more for lard.

Our imports last year were as follows:—

	Cwts.	Value.
Bacon	3,498,144	£7,287,207
Hams	977,608	2,501,484
Lard	1,193,831	2,178,408
Pork (fresh and salted)	386,433	676,404
Swine (No.) 25,324	—	95,373
Total cwts.	6,056,016	12,738,876

The home consumption of imported bacon and hams in the last few years has averaged 11 lbs. per head of the total population of the United Kingdom. But there are about 2,500,000 pigs also in the United Kingdom, most of which go to the butcher yearly.

But this number is small compared with the number of pigs kept in the United States. The swine there number 51,500,000, more by 30,000,000 than we have of sheep in the United Kingdom. But, then, North America produces more than 2,000,000,000 bushels of maize, which, if not converted chiefly into pork and lard, would have to be turned into cornflour, or made into glucose, or used as fuel, as has been often the case when corn could not be sold at a profit.

The value of the exports of the hog from the United States seems to have declined by about £5,000,000 sterling in the last ten years, as the following official figures show:—

	1878.	1887.
Bacon and hams	$51,752,068	$22,315,000
Pork	4,913,657	5,641,000
Lard	30,014,254	22,704,000
	$86,679,979	61,660,000
	£17,333,999	12,332,000

The enormous increase in our consumption of foreign bacon and hams, up to 1880, is worth special notice. Taken in decennial periods, the numbers have been as follows, in cwts.:—

	Bacon and Hams.	Pork.
1840	6,181	29,532
1850	352,461	211,254
1860	326,106	173,325
1870	567,164	257,014
1880	4,910,689	409,267
1889	4,475,752	386,433

Hogs well fed supply healthful, sustaining, and delicate food, heat-giving, compact, and with properties for long preservation by salt and smoke, something that the sailor, and the wayfarer can carry with them and find much sustenance in little space. Whether salted and called "pork," or smoked and called "bacon," this is a flesh which the working man and the villager could not do without. The home consumption of pork in America is as large as the export, and visitors to the American International Exhibition at Chicago will have an opportunity of witnessing hog slaughtering and pork packing in that City on an extensive scale.

The French *Foire aux Jambons*, held in Paris in Lent, is one of the most ancient and almost the most popular and successful of French fairs. The sales in the three days of the fair amount to many hundred tons to supply the numerous *charcuteries* of Paris, of which there are more than 200 in the City.

TECHNICAL INSTRUCTION AT OXFORD AND ROCHDALE.

The Lords of the Committee of her Majesty's Most Honourable Privy Council on Education have received letters from the Town Clerks of Oxford and Rochdale, stating that their respective Town Councils propose to make grants under the powers conferred upon them by the Technical Instruction Act, 1889.

The Town Clerk of Oxford states that the Town Council of that city propose to make grants to the School of Science and Art in Oxford for the promotion of technical instruction; that at that institution instruction is given in the following subjects, which are not included in the branches of science and art with respect to which grants are at present made by the Department of Science and Art, viz.:—(1) Wood-carving, with lessons in design; (2) drawing to scale, as applied to practical work; (3) manual training in the use of tools for working in wood and iron; and that the circumstances of the district require facilities for instruction in these subjects.

The Town Clerk of Rochdale states that the Town Council of that borough propose to make grants to certain institutions in Rochdale for the promotion of technical instruction; that at one of these institutions instruction is given in the following subjects, which are not included in the branches of science and art with respect to which grants are at present made by the Deparment of Science and Art, viz.:—(1) Cotton-spinning; (2) cotton-weaving: (3) cloth-weaving; (4) plumbers' work; and that, in the opinion of the Town Council, such a form of instruction is required by the circumstances of its district.

In accordance with these requests My Lords are pleased to sanction these forms of instruction under Clause 8 of the Technical Instruction Act, 1889.

FEATHER FACTORIES IN GERMANY.

The United States Consul at Mannheim says that in Mannheim and the neighbourhood there are several large factories worked by steam, with enormous machines employing hundreds of hands, engaged in preparing feathers for market. The feathers come in great quantities from Russia, Austria, and other parts of Europe, and also Asia, China especially sending vast quantities in a very dirty condition. The feathers come into the factory in large bales. These are opened near a kind of gin or breaker, which separates the feathers from a lumpy or bunchy form, and flings them around in an air filled chamber, through which a constant current is blowing. From this machine they go to another, in which, by means of ventilators, a separation of the short and light feathers from the long and heavy is made. Stage after stage, through machines arranged and shaped much like cotton gins, the feathers fly, each machine separating the lighter from the heavier, until the most delicate, flaky, snow down, is flung out into a large chamber. In one stage of the process, the feathers are cleansed. This is done by placing them in a large steam-heated boiler, into which steam is projected, and made to cleanse every particle of dirt from the feathers. Long before the feathers get time to be wet through by the steam dry air is injected from one side, while suction currents draw off every particle of dust or dirt loosened by the steam. The largest feathers, those which on account of the long quills are unfitted for use, are sent to the State prisons, where for very small sums, the "wings" are carefully torn from the quills and returned to the factory, where they are cleansed and prepared for market. Most of the factories endeavour to get out of the feathers as much as possible of the down. A very fine quality of this article, that of the eider duck, fetches as much as 35s. a pound. The machines are very simple in character and construction, and require in their working no special skill. They consist of breakers and ventilators. Contrivances for catching dust have been invented, but never any so skilfully contrived as to keep the fine particles from finding their way into the open rooms and thence into the lungs of the workpeople. The machines are not patented, the demand not being large enough to warrant the expense of obtaining and maintaining patent rights.

Notes on Books.

THE JOURNAL OF INDIAN ART. Vol. III., No. 31. July, 1890. London: W. Griggs.

This number contains an account of the East India Company by Sir George Birdwood, which is illustrated by a series of fac-similes of charters, grants, letters, views, &c. These consist of the following important documents:—Coat of Arms of the Old East India Company; special licence to the East Indies merchants, 1610; map of the Island of Bombay, 1626; warrant from Oliver Cromwell; charters, 1661, 1677, 1693, 1698; first page of original subscribers' fund, 1698; grant of arms to the New East India Company, 1698; thanks to Nelson and Nelson's acknowledgment, 1799; grant of arms to Haileybury College, 1807; views of Crosby-house, which was used by the Company, and the old house in Leadenhall-street, occupied from 1648 to 1726. Malton's coloured engravings of the India-house in 1726 and 1796 are reproduced in colours, and the series of illustrations is completed by plates of the handsome mantel-pieces removed from the East India-house to the India-office, and views of the interior of the quadrangle and exterior of the India-office. Some of these documents were referred to in Mr. F. C. Danvers' paper on the "India-office Records," read before the Indian Section on January 17th last (see *ante*, p. 159).

INORGANIC CHEMISTRY, THEORETICAL AND PRACTICAL. A Manual for Students in Advanced Classes. By William Jago, F.C.S., F.I.C. London: Longmans, Green and Co. 1890. Sm. 8vo.

The author has attempted in this work to meet the requirements of the students in the advanced chemistry classes of the Science and Art Department, and while beginning at the commencement of the science, he has assumed that the reader has such knowledge as is conveyed in his own elementary text-book, The book is fully illustrated, and a folding table of emission and absorption spectra by Mr. Norman Lockyer forms the frontispiece.

THE LABOUR MOVEMENT IN AMERICA. By Richard T. Ely, Ph.D. London: William Heinemann. 1890. Sm. 8vo.

An attempt is here made to give a preliminary sketch of the subject, which the author hopes to follow up at some future time by a "History of Labour in the New World." In the successive chapters Dr. Ely deals with the economic value of labour organisations, and also their educational value, and with co-operation in America; several chapters are devoted to the various phases of Socialism.

General Notes.

CARD INDEX TO PERIODICAL LITERATURE.—The Newspaper Extract and Special Information Agency have lent one of their cabinets containing a Card Index to the Periodical Literature of Applied Science, which is now placed in the Society's Library. The cabinet contains specimen cards on various subjects, and a current index on oxidizing agents, and on india-rubber.

Journal of the Society of Arts.

No. 1,972. Vol. XXXVIII.

FRIDAY, SEPTEMBER 5, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

"OWEN JONES" PRIZES.

This competition was instituted in 1878, by the Council of the Society of Arts, as trustees of the sum of £400, presented to them by the Owen Jones Memorial Committee, being the balance of subscriptions to that fund, upon condition of their expending the interest thereof in prizes to "Students of the School of Art who, in annual competition, produce the best design for Household Furniture, Carpets, Wall-papers and Hangings, Damask, Chintzes, &c., regulated by the principles laid down by Owen Jones." The prizes are awarded on the results of the annual competition of the Science and Art Department.

Six prizes were offered for competition in the present year, each prize consisting of a bound copy of Owen Jones's "Principles of Design," and a Bronze Medal.

The following is a list of the successful candidates :—

William E. Holt, School of Art, Burnley.—Design for a printed cotton hanging.

Archibald Walker, School of Art, Glasgow.—Design for carpets.

Lindsay Butterfield, School of Art, South Kensington.—Designs for printed tiles.

Mary Mohun, School of Art, Canterbury.—Design for damask; design for tiles.

William H. Cantrill, School of Art, Cavendish-street, Manchester.—Designs for the decoration of a staircase and proscenium of Manchester School of Art.

Emma Hodgkinson, School of Art, Cavendish-street, Manchester.—Design for carpet.

The next award will be made in 1891, when six prizes will be offered for competition.

Proceedings of the Society.

CANTOR LECTURES.

THE ELECTROMAGNET.

By Professor Silvanus P. Thompson, D.Sc., B.A., M.I.E.E.

Lecture I.—Delivered January 20th, 1890.

Historical Introduction—Generalities about Forms and Uses of Electromagnets—The Magnetic Properties of Iron.

Introductory.

Amongst the great inventions which have originated in the lecture-room in which we are met are two of special interest to electricians—the application of gutta-percha to the purpose of submarine telegraph cables, and the electromagnet. This latter invention was first publicly described, from the very platform on which I stand, on May 23rd, 1825, by William Sturgeon, whose paper is to be found in the forty-third volume of the Transactions of the Society of Arts. For this invention we may rightfully claim the very highest place. Electrical engineering, the latest and most vigorous offshoot of applied science, embraces many branches. The dynamo for generating electric currents, the motor for transforming their energy back into work, the arc lamp, the electric bell, the telephone, the recent electromagnetic machinery for coal mining, for the separation of ore, and many other electromechanical contrivances, come within the purview of the electrical engineer. In every one of these, and in many more of the useful applications of electricity, the central organ is an electromagnet. By means of this simple and familiar contrivance—an iron core surrounded by a copper wire coil—mechanical actions are produced at will, at a distance, under control, by the agency of electric currents. These mechanical actions are known to vary with the mass, form, and quality of the iron core, the quantity and disposition of the copper wire wound upon it, the quantity of electric current circulating around it, the form, quality, and distance of the iron armature upon which it acts. But the laws which govern the mechanical action in relation to these various matters are by no means well known, and, indeed, several of them have long been a matter of dispute. Gradually, however, that which has been vague and indeterminate becomes clear and precise. The laws of the steady circulation of electric currents, at one time altogether obscure, were cleared up by the discovery of the famous law of Ohm. Their extension to the case of rapidly interrupted currents, such as are used in telegraphic working, was discovered by Helmholtz; whilst to Maxwell is due their further extension to alternating, or, as they are sometimes called, undulatory currents. All this was purely electric work. But the law of the electromagnet was still undiscovered; the magnetic part of the problem was still buried in obscurity. The only exact reasoning about magnetism dealt with problems of another kind; it was couched in language of a misleading character; for the practical problems connected with the electromagnet it was worse than useless. The doctrine of two magnetic fluids distributed over the end surfaces of magnets, which under the sanction of the great names of Coulomb, of Poisson, and of Laplace, had unfortunately become recognised as an accepted part of science, along with the law of inverse squares. How greatly the progress of electromagnetic science has been impeded and retarded by the weight of these great names it is impossible now to gauge. We now know that for all purposes, save only those whose value lies in the domain of abstract mathematics, the doctrine of the two magnetic fluids is false and misleading. We know that magnetism, so far from residing on the end or surface of the magnet, is a property resident throughout the mass; that the internal not the external magnetisation is the important fact to be considered; that the so-called free magnetism on the surface is, as it were, an accidental phenomenon; that the magnet is really most highly magnetised at those parts where there is least surface magnetisation; finally, that the doctrine of surface distribution of fluids is absolutely incompetent to afford a basis of calculation such as is required by the electrical engineer. He requires rules to enable him not only to predict the lifting power of a given electromagnet, but also to guide him in designing and constructing electromagnets of special forms suitable for the various cases that arise in his practice. He wants in one place a strong electromagnet to hold on to its armature like a limpet to its native rock; in another case he desires a magnet having a very long range of attraction, and wants a rule to guide him to the best design; in another he wants a special form having the most rapid action attainable; in yet another he must sacrifice everything else to attain maximum action with minimum weight. Toward the solution of such practical problems as these the old theory of magnetism offered not the slightest aid. Its array of mathematical symbols was a mockery. It was as though an engineer asking for rules to enable him to design the cylinder and piston of an engine were confronted with receipts how to estimate the cost of painting it.

Gradually, however, new light dawned. It became customary, in spite of the mathematicians, to regard the magnetism of a magnet as something that traverses or circulates around a definite path, flowing more freely through such substances as iron, than through other relatively non-magnetic materials. Analogies between the flow of electricity in an electrically-conducting circuit, and the passage of magnetic lines of force through circuits possessing magnetic conductivity, forced themselves upon the minds of experimenters, and compelled a mode of thought quite other than the previously accepted. So far back as 1821, Cumming* experimented on magnetic conductivity. The idea of a magnetic circuit was more or less familiar to Ritchie,† Sturgeon,‡ Dove,§ Dub,‖ and De La Rive,¶ the last-named of whom explicitly uses the phrase, "a closed magnetic circuit." Joule** found the maximum power of an electromagnet to be proportional to "the least sectional area of the entire magnetic circuit," and he considered the resistance to induction as proportional to the length of the magnetic circuit. Indeed, there are to be found scattered in Joule's writings on the subject of magnetism, some five or six sentences, which, if collected together, constitute a very full statement of the whole matter. Faraday,†† considered that he had proved that each demagnetic line of force constitutes a closed curve; that the path of these closed curves depended on the magnetic conductivity of the masses disposed in proximity; that the lines of magnetic force were strictly analogous to the lines of electric flow in an electric circuit. He spoke of a magnet surrounded by air being like unto a voltaic battery immersed in water or other electrolyte. He even saw the existence of a power, analogous to that of electromotive-force in electric circuits, though the name, "magneto-motive force," is of more recent origin. The notion of magnetic conductivity is to be found in Maxwell's great treatise (vol. ii., p. 51), but is only briefly mentioned. Rowland,[*] in 1873, expressly adopted the reasoning and language of Faraday's method in the working out of some new results on magnetic permeability, and pointed out that the flow of magnetic lines of force through a bar could be subjected to exact calculation; the elementary law, he says, "is similar to the law of Ohm." According to Rowland, the "magnetizing force of helix" was to be divided by the "resistance to the lines of force;" a calculation for magnetic circuits which every electrician will recognise as precisely as Ohm's law for electric circuits. He applied the calculations to determine the permeability of certain specimens of iron, steel, and nickel. In 1882,[†] and again in 1883, Mr R. H. M. Bosanquet[‡] brought out at greater length a similar argument, employing the extremely apt term "Magneto-motive Force," to connote the force tending to drive the magnetic lines of induction through the "magnetic resistance" or, as it will be frequently called in these Lectures, the magnetic "reluctance" of the circuit. In these papers the calculations are reduced to a system, and deal not only with the specific properties of iron, but with problems arising out of the shape of the iron. Bosanquet shows how to calculate the several resistances (or reluctances) of the separate parts of the circuit, and then add them together to obtain the total resistance (or reluctance) of the magnetic circuit.

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* "Camb. Phil. Trans.," April 2, 1821.

† "Phil. Mag.," series iii., vol. iii., p. 122.

‡ "Ann. of Electr.," xii., p. 217.

§ "Pogg. Ann.," xxix., p. 462, 1833. See also "Pogg. Ann.," xliii., p. 517, 1838.

‖ "Dub. Elektromagnetismus" (ed. 1861), p. 401; and "Pogg. Ann.," xc., p. 440, 1853.

¶ De La Rive. "Treatise on Electricity" (Walker's translation), vol. 1, p. 292.

** "Ann. of Electr.," iv., 59, 1839; v., 195, 1841; and "Scientific Papers," pp. 8, 34, 35, 36.

†† "Experimental Researches," vol. iii., art. 3117, 3228, 3230, 3260, 3271, 3276, 3294, and 3361.

Prior to this, however, the principle of the magnetic circuit had been seized upon by Lord Elphinstone and Mr. Vincent, who proposed to apply it in the construction of the dynamo-electric machines. On two occasions[*] they communicated to the Royal Society the results of experiments to show that the same exciting current would evoke a larger amount of magnetism in a given iron structure, if that iron structure formed a closed magnetic circuit, than if it were otherwise disposed.

In recent years the notion of the magnetic circuit has been vigorously taken up by the designers of dynamo-machines, who indeed base the calculation of their designs upon this all-important principle. Having this, they need no laws of inverse squares of distances, no magnetic moments, none of the elaborate expressions for surface distribution of magnetism, none of the ancient paraphernalia of the last century. The simple law of the magnetic circuit and a knowledge of the properties of iron are practically all they need. About four years ago, much was done by Mr. Gisbert Kapp[†] and by Drs. J. and E. Hopkinson[‡] in the application of these considerations to the design of dynamo-machines, which previously had been a matter of empirical practice. To this end the formulæ of Professor Forbes[§] for calculating magnetic leakage, and the researches of Professors Ayrton and Perry[||] on magnetic shunts, contributed a not unimportant share. As the result of the advances made at that time, the subject of dynamo design was reduced to an exact science.

It is the aim and object of the present course of lectures to show how the same considerations which have been applied with such great success to the subject of the design of dynamo-electric machines may be applied to the study of the electromagnet. The theory and practice of the design and construction of electromagnets will thus be placed, once for all, upon a rational basis. Definite rules will be laid down for the guidance of the constructor, directing him as to the proper dimensions and form of iron to be chosen, and as to the proper size and amount of copper wire to be wound upon it in order to produce any desired result.

First, however, a historical account of the invention will be given, followed by a number of general considerations respecting the uses and forms of electromagnets. These will be followed by a discussion of the magnetic properties of iron and steel and other materials; some account being added of the methods used for determining the magnetic permeability of various brands of iron at different degrees of saturation. Tabular information is given as to the results found by different observers. In connection with the magnetic properties of iron the phenomenon of magnetic hysteresis is also described and discussed. The principle of the magnetic circuit is then discussed with numerical examples, and a number of experimental data respecting the performance of electromagnets are adduced, in particular those bearing upon the tractive power of electromagnets. The law of traction between an electromagnet and its armature is then laid down, followed by the rules for predetermining the iron cores and copper coils required to give any prescribed tractive force.

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[*] "Phil. Mag., series iv., vol. xlvi , August 1873, "On Magnetic Permeability and the Maximum of Magnetism of Iron, Steel, and Nickel."

[†] "Proc. Royal Soc.," xxxiv., p. 445, December, 1882.

[‡] "Phil. Mag.," series v., vol. xv., p. 205, March, 1883. "On Magneto-Motive Force." Also *ib.*, vol. xix., February, 1885, and "Proc. Roy. Soc ," No. 223, 1883. See also "Electrician," xiv., p. 291, February 14th, 1885.

[*] "Proc. Roy. Soc.," xxix., p. 292, 1879, and xxx., p. 287, 1880. See "Electrical Review," viii., p. 134, 1880.

[†] "The Electrician," vols. xiv., xv., and xvi., 1885-6; also "Proc. Inst. Civil Engineers," lxxxiii., 1885-6; and "Journ. Soc. Telegr. Engineers," xv., 524, 1886.

[‡] "Phil. Trans.," 1886, pt. i., p. 331; and "The Electrician," xviii., pp. 39, 63, 86, 1886.

[§] "Journ. Soc. Telegr. Engineers," xv., 555, 1886.

[||] "Journ. Soc. Telegr. Engineers," xv., 530, 1886.

Then comes the extension of the calculation of the magnetic circuit to those cases where there is an air gap between the poles of the magnet and the armature; and where, in consequence, there is leakage of the magnetic lines from pole to pole. The rules for calculating the winding of the copper coils are stated, and the limiting relation between the magnetizing power of the coil and the heating effect of the current in it is explained. After this comes a detailed discussion of the special varieties of form that must be given to electromagnets in order to adapt them to special services. Those which are designed for maximum traction, for quickest action, for longest range, for greatest economy when used in continuous daily service, for working in series with constant current, for use in parallel at constant pressure, and those for use with alternate currents, are separately considered.

Lastly, some account is given of the various forms of electromagnetic mechanism which have arisen in connection with the invention of the electromagnet. The plunger and coil is specially considered as constituting a species of electromagnet adapted for a long range of motion. Modes of mechanically securing long range for electromagnets, and of equalising their pull over the range of motion of the armature, are also described. The analogies between sundry electro-mechanical movements and the corresponding pieces of ordinary mechanism are traced out. The course is concluded by a consideration of the various modes of preventing or minimising the sparks which occur in the circuits in which electromagnets are used.

HISTORICAL SKETCH.

The effect which an electric current, flowing in a wire, can exercise upon a neighbouring compass needle was discovered by Oersted in 1820.[*] This first announcement of the possession of magnetic properties by an electric current was followed speedily by the researches of Ampere,[†] Arago,[‡] Davy,[§] and by the devices of several other experimenters, including De la Rive's[||] floating battery and coil, Schweigger's[¶] multiplier, Cumming's[**] galvanometer, Faraday's[††] apparatus for rotation of a permanent magnet, Marsh's[‡‡] vibrating pendulum, and Barlow's[§§] rotating star-wheel. But it was not until 1825 that the electromagnet was invented. Davy had, indeed, in 1821 surrounded with temporary coils of wire the steel needles upon which he was experimenting, and had shown that the flow of electricity around the coil could confer magnetic power upon the steel needles. But from this experiment it was a grand step forward to the discovery that a core of soft iron, surrounded by its own appropriate coil of copper, could be made to act not only as a powerful magnet, but as a magnet whose power could be turned on or off at will, could be augmented to any desired degree, and could be set into action and controlled from a practically unlimited distance.

The electromagnet, in the form which can first claim recognition for these qualities, was devised by William Sturgeon,[||||] and is de-

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[*] See Thomson's "Annals of Philosophy," Oct., 1820.

[†] "Ann. de Chim. et de Physique," xv., 59 and 170, 1820.

[‡] *ib.*, xv., 93, 1820.

[§] "Phil. Trans.," 1821.

[||] Bibliothèque Universelle," March, 1821.

[¶] *ib.*

[**] "Camb. Phil. Trans.," 1821.

[††] "Quarterly Journal of Science," Sept., 1821.

[‡‡] Barlow's "Magnetic Attractions," second edition, 1823.

[§§] *ib.*

[||||] William Sturgeon, the inventor of the electromagnet, was born at Whittington, in Lancashire, in 1783. Apprenticed as a boy to the trade of a shoemaker, at the age of nineteen he joined the Westmoreland Militia, and two years later enlisted into the Royal Artillery, thus gaining the chance of learning something of science, and having leisure in which to pursue his absorbing passion for chemical and physical experiments. He was forty-two years of age when he made his great, though at the time unrecognised, invention. At the date of his researches in electromagnetism he was resident at 8, Artillery-place, Woolwich, at which place he was the associate of Marsh, and was intimate with Barlow, Christie, and Gregory, who interested themselves in his work. In 1835 he presented a paper to the Royal Society containing descriptions, *inter alia*, of a magneto-electric machine with longitudinally-wound armature, and with a commutator consisting scribed by him in the paper which he contributed to the proceedings of the Society of Arts in 1825, accompanying a set of improved apparatus for electromagnetic experiments.[*] The Society of Arts rewarded Sturgeon's labours by awarding him the silver medal of the Society and a premium of thirty guineas. Amongst this set of apparatus are two electromagnets, one of horse-shoe shape (Figs. 1 and 2) and one a straight bar (Fig. 3). It will be seen that the former figures represent an electromagnet consisting of a bent iron rod about one foot long and half inch in diameter, varnished over and then coiled with a single left-handed spiral of stout uncovered copper wire of 18 turns. This coil was found appropriate to the particular battery which Sturgeon preferred, namely, a single cell containing a spirally enrolled pair of zinc and copper plates of large area (about 130 square inches) immersed in acid; which cell, having small internal resistance, would yield a large quantity of current when connected to a circuit of small resistance. The ends of the copper wire were brought out sideways and bent down so as to dip into two deep connecting cups, marked Z and C, fixed upon a wooden stand. These cups, which were of wood, served as supports to hold up the electromagnet, and having mercury in them served also to make good electrical connection. In Fig. 2, the magnet is seen sideways, supporting a bar of iron, *y*. The circuit was completed to the battery through a connecting wire, *d*, which could be lifted out of the cup, Z, so breaking circuit when desired, and allowing the weight to drop. Sturgeon added in his explanatory remarks that the poles, N and S, of the magnet will be reversed if you wrap the copper wire about the rod as a right-handed screw, instead of a left-handed one, or, more simply, by reversing the connections with the battery, by causing the wire that dips into the Z cup to dip into the C cup, and *vice-versa*. This electromagnet was capable of supporting nine pounds when thus excited.

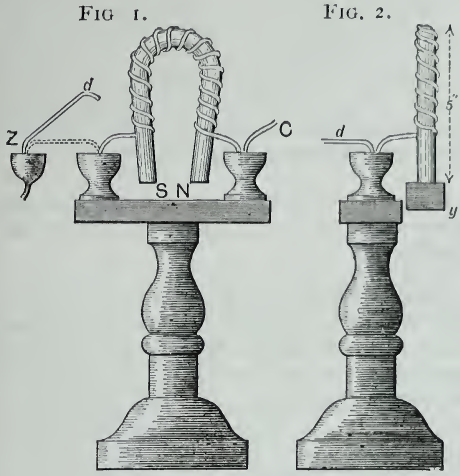
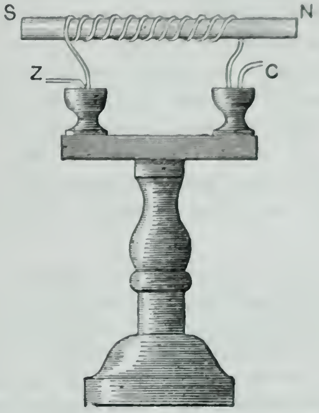


FIG 1. FIG. 2.

STURGEON'S FIRST ELECTROMAGNET.

FIG. 3.



STURGEON'S STRAIGHT BAR ELECTROMAGNET.

Fig. 3 shows another arrangement to fit on the same stand. "This arrangement communicates magnetism to hardened steel bars, as soon as they are put in, and renders soft iron within it magnetic during the time of action; it only differs from Figs. 1 and 2 in being straight, and thereby allows the steel or iron bars to slide in and out.

For this piece of apparatus and other adjuncts accompanying it, all of which are described in the Society's "Transactions" for 1825, Sturgeon, as already stated, was awarded the Society's silver medal and a premium of thirty guineas. The apparatus was deposited in the museum of the Society, which therefore

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of half-disks of metal. For some reason this paper was not admitted to the "Philosophical Transactions;" he afterwards printed it in full, without alteration, in his volume of Scientific Researches, published by subscription in 1850. From 1836 to 1843 he conducted the "Annals of Electricity." He had now removed to Manchester, where he lectured on electricity at the Royal Victoria Gallery. He died at Prestwich, near Manchester, in 1850. There is a tablet to his memory in the church at Kirkby Lonsdale, from which town the village of Whittington is distant about two miles. A portrait of Sturgeon in oils, and said to be an excellent likeness, is believed still to be in existence; but all inquiries as to its whereabouts have proved unavailing. At the present moment, so far as I am aware, the scientific world is absolutely without a portrait of the inventor of the electromagnet.

[*] "Trans. Society of Arts," 1825, xliii, p. 38.

might be supposed to be the proud possessor of the first electromagnet ever constructed. Alas for the vanity of human affairs, the Society's museum of apparatus has long been dispersed, this priceless relic having been either made over to the now defunct Patent-office Museum, or otherwise lost sight of.

Sturgeon's first electromagnet, the core of which, weighing about 7 oz., was able to sustain a load of 9 lbs., or about 20 times its own weight. At the time it was considered a truly remarkable performance. Its single layer of stout copper wire was well adapted to the battery employed, a single cell of Sturgeon's own particular construction, having a surface of 130 sq. inches, and therefore of small internal resistance. Subsequently in the hands of Joule, the same electromagnet sustained a load of 50 lbs., or about 114 times its own weight. Writing in 1832 about his apparatus of 1825, Sturgeon used the following magniloquent language :—

"When first I showed that the magnetic energies of a galvanic conducting wire are more conspicuously exhibited by exercising them on soft iron than on hard steel, my experiments were limited to small masses—generally to a few inches of rod iron about half an inch in diameter. Some of those pieces were employed while straight, and others were bent into the form of a horse-shoe magnet, each piece being encompassed by a spiral conductor of copper wire. The magnetic energies developed by these simple arrangements are of a very distinguished and exalted character, as is conspicuously manifested by the suspension of a considerable weight at the poles during the period of excitation by the electric influence.

"An unparallelled transiliensy of magnetic action is also displayed in soft iron, by an instantaneous transition from a state of total inactivity to that of vigorous polarity, and also by a simultaneous reciprocity of polarity in the extremities of the bar—versatilities in this branch of physics for the display of which soft iron is pre-eminently qualified, and which, by the agency of electricity, become demonstrable with the celerity of thought, and illustrated by experiments the most splendid in magnetics. It is, moreover, abundantly manifested by ample experiments, that galvanic electricity exercises a superlative degree of excitation on the latent magnetism of soft iron, and calls for its recondite powers with astonishing promptitude, to an intensity of action far surpassing anything which can be accomplished by any known application of the most vigorous permanent magnet, or by any other mode of experimenting hitherto discovered. It has been observed, however, by experimenting on different pieces selected from various sources, that, notwithstanding the greatest care be observed in preparing them of a uniform figure and dimensions, there appears a considerable difference in the susceptibility which they individually possess of developing the magnet powers, much of which depends upon the manner of treatment at the forge, as well as upon the natural character of the iron itself.*

"The superlative intensity of electromagnets, and the facility and promptitude with which their energies can be brought into play, are qualifications admirably adapted for their introduction into a variety of arrangements in which powerful magnets so essentially operate, and perform a distinguished part in the production of electromagnetic rotations; whilst the versatilities of polarity of which they are susceptible are eminently calculated to give a pleasing diversity in the exhibition of that highly interesting class of phenomena, and lead to the production of others inimitable by any other means."†

Sturgeon's further work during the next three years is best described in his own words :—

"It does not appear that any very extensive experiments were attempted to improve the lifting power of electromagnets, from the time that my experiments were published in the 'Transactions of the Society of Arts, &c.,' for 1825, till the latter part of 1828. Mr. Watkins, philosophical instrument maker, Charing-cross, had, however, made them of much larger size than any which I had employed, but I am not aware to what extent he pursued the experiment.

"In the year 1828, Professor Moll, of Utrecht, being on a visit to London, purchased of Mr. Watkins an electromagnet weighing about 5 lbs.—at that time I believe the largest which had been made. It was of round iron, about one inch in diameter, and furnished with a single copper wire twisted round it eighty-three times. When this magnet was excited by a large galvanic surface, it supported about 75 lbs. Professor Moll afterwards prepared another electromagnet, which, when bent, was 12½ inches high, 2½ inches in diameter, and weighed about 26 lbs; prepared like the former with a single spiral conducting wire. With an acting galvanic surface of 11 square feet, this magnet would support 154 lbs., but would not lift an anvil which weighed 200 lbs.

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* "I have made a number of experiments on small pieces, from the results of which it appears that much hammering is highly detrimental to the development of magnetism in soft iron, whether the exciting cause be galvanic or any other. And although good annealing is always essential, and facilitates to a considerable extent the display of polarity, that process is very far from restoring to the iron that degree of susceptibility which it frequently loses by the operation of the hammer. Cylindric rod iron of small dimensions may very easily be bent into the required form, without any hammering whatever; and I have found that small electromagnets made in this way display the magnetic powers in a very exalted degree."

† Sturgeon's "Scientific Researches," p. 113.

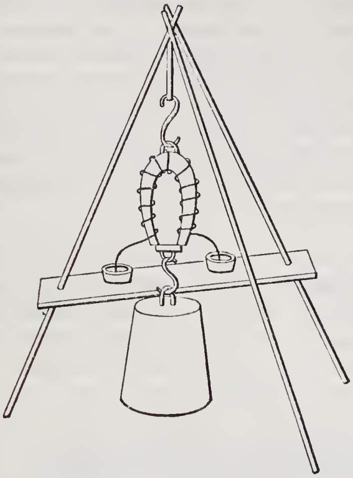
"The largest electromagnet which I have yet [1832] exhibited in my lectures weighs about 16 lbs. It is formed of a small bar of soft iron, 1½ inch across each side; the cross piece, which joins the poles, is from the same rod of iron, and about 3¾ inches long. Twenty separate strands of copper wire, each strand about fifty feet in length, are coiled round the iron, one above another, from pole to pole, and separated from each other by intervening cases of silk: the first coil is only the thickness of one ply of silk from the iron; the twentieth, or outermost, about half-an-inch from it. By this mean the wires are completely insulated from each other without the trouble of covering them with thread or varnish. The ends of wire project about two feet for the convenience of connection. With one of my small cylindrical batteries, exposing about 150 square inches of total surface, this electromagnet supports 400 lbs. I have tried it with a larger battery, but its energies do not seem to be so materially exalted as might have been expected by increasing the extent of galvanic surface. Much depends upon a proper acid solution; good nitric or nitrous acid, with about six or eight times its quantity of water, answers very well. With a new battery of the above dimensions and a strong solution of salt and water, at a temperature of 190° Fahr., the electromagnet supported between seventy and eighty pounds, when the first seventeen coils only were in the circuit. With the three exterior coils alone in the circuit, it would just support the lifter, or cross piece. When the temperature of the solution was between 40° and 50°, the magnetic force excited was comparatively very feeble. With the innermost coil alone and a strong acid solution this electromagnet supports about 100 lbs.: with the four outermost wires about 250 lbs. It improves in power with every additional coil until about the twelfth, but not perceptibly any further; therefore the remaining eight coils appear to be useless, although the last three, independently of the innermost seventeen, and at the distance of half-an-inch from the iron, produce in it a lifting power of 75 lbs.

"Mr. Marsh has fitted up a bar of iron much larger than mine, with a similar distribution of the conducting wires to that devised and so successfully employed by Professor Henry. Mr. Marsh's electromagnet will support about 560 lbs. when excited by a galvanic battery similar to mine. These two, I believe, are the most powerful electromagnets yet produced in this country.

"A small electromagnet, which I also employ on the lecture table, and the manner of its suspension is represented by Fig. 4. The magnet is of cylindric rod iron, and weighs four ounces; its poles are about a quarter of an inch asunder. It is furnished with six coils of wire in the same manner as the large electromagnet before described, and will support upwards of 50 lbs.

"I find a triangular gin very convenient for the suspension of the magnet in these experiments. A stage of thin board, supporting two wooden dishes, fastened, at a proper height, to two of the legs of the gin. Mercury is placed in these vessels, and the dependent amalgamated extremities of the conducting wires dip into it—one into each portion.

FIG. 4.



STURGEON'S LECTURE-TABLE ELECTROMAGNET.

"The vessels are sufficiently wide to admit of considerable motion of the wires in the mercury without interrupting the contact, which is sometimes occasioned by the swinging of the magnet and attached weight. The circuit is completed by other wires, which connect the battery with these two portion of mercury. When the weight is supported as in the Figure, if an interruption be made by removing either of the connecting wires, the weight instantaneously drops on the table. The large magnet I suspend in the same way on a larger gin; the weights which it supports are placed one after another on a square board, suspended by means of a cord at each corner from a hook in the cross piece, which joins the poles of the magnet.

"With a new battery, and a solution of salt and water, at a temperature of 190° Fahr, the small electromagnet, Fig. 3, supports 16 lbs."

In 1840, after Sturgeon had removed to Manchester, where he assumed the management of the "Victoria Gallery of Practical Science," he continued his work, and in the seventh memoir in his series of researches he wrote as follows:—

"The electromagnet belonging to this Institution, is made of a cylindrical bar of soft iron, bent into the form of a horse-shoe magnet, having the two branches parallel to each other, and at the distance of 4·5 inches. The diameter of the iron is 2·75 inches, it is 18 inches long when bent. It is surrounded by fourteen coils of copper wire, seven on each branch. The wire which constitutes the coils is 1-12th of an inch diameter, and in each coil there are about seventy feet of wire. They are united in the usual way with branch wires, for the purpose of conducting the currents from the battery. The magnet was made by Mr. Nesbit. . . . The greatest weight sustained by the magnet in these experiments is $12\frac{3}{4}$ cwt., or 1,386 lbs., which was accomplished by sixteen pairs of plates, in four groups of four pairs in series each. The lifting power by nineteen pairs in series was considerably less than by ten pairs in series; and but very little greater than that given by one cell or one pair only. This is somewhat remarkable, and shows how easily we may be led to waste the magnetic powers of batteries by an injudicious arrangement of its elements."[*]

At the date of Sturgeon's work the laws governing the flow of electric currents in wires were still obscure. Ohm's epoch-making enunciation of the law of the electric circuit appeared in "Poggendorff's Annalen" in the very year of Sturgeon's discovery, 1825, though his complete book appeared only in 1827, and his work, translated by Dr. Francis into English, only appeared (in Taylor's "Scientific Memoirs," vol. ii.) in 1841. Without the guidance of Ohm's law it was not strange that even the most able experimenters should not understand the relations between battery and circuit which would give them the best effects. These had to be found by the painful method of trial and failure. Pre-eminent amongst those who tried was Professor Joseph Henry, then of the Albany Institute, in New York, later of Princeton, New Jersey, who succeeded in effecting an important improvement. In 1828, led on by a study of the "multiplier" (or galvanometer), he proposed to apply to electromagnetic apparatus the device of winding them with a spiral coil of wire "closely turned on itself," the wire being of copper from 1-40th to 1-25th of an inch in diameter, covered with silk. In 1831 he thus describes[†] the results of his experiments:—

"A round piece of iron, about $\frac{1}{4}$ of an inch in diameter, was bent into the usual form of a horseshoe, and instead of loosely coiling around it a few feet of wire, as is usually described, it was tightly wound with 35 feet of wire, covered with silk, so as to form about 400 turns; a pair of small galvanic plates, which could be dipped into a tumbler of diluted acid, was soldered to the ends of the wire, and the whole mounted on a stand. With these small plates the horse-shoe became much more powerfully magnetic than another of the same size, and wound in the same manner, by the application of a battery composed of 28 plates of copper and zinc, each 8 inches square. Another convenient form of this apparatus was contrived by winding a straight bar of iron, 9 inches long, with 35 feet of wire, and supporting it horizontally on a small cup of copper containg a cylinder of zinc—when this cup, which served the double purpose of a stand and the galvanic element, was filled with dilute acid, the bar became a portable electromagnet. These articles were exhibited to the Institute in March, 1829. The idea afterwards occurred to me, that a sufficient quantity of galvanism was furnished by the two small plates, to develop, by means of the coil, a much greater magnetic power in a larger piece of iron. To test this, a cylindrical bar of iron, $\frac{1}{2}$ an inch in diameter, and about 10 inches long, was bent into the shape of a horse-shoe, and wound with 30 feet of wire; with a pair of plates containing only $2\frac{1}{2}$ square inches of zinc, it lifted 15 lbs. avoirdupois. At the same time, a very material improvement in the formation of the coil suggested itself to me on reading a more detailed account of Professor Schweigger's galvanometer, and which was also tested with complete success upon the same horseshoe; it consisted in using several strands of wire, each covered with silk, instead of one. Agreeably to this construction, a second wire, of the same length as the first, was wound over it, and the ends soldered to the zinc and copper in such a manner that the galvanic current might circulate in the same direction in both, or, in other words, that the two wires might act as one; the effect by this addition was doubled, as the horse-shoe, with the same plates before used, now supported 28 lbs.

"With a pair of plates 4 inches by 6 inches, it lifted 39 lbs., or more than fifty times its own weight.

"These experiments conclusively proved that a great development of magnetism could be effected by a very small galvanic element, and also that the power of the coil was materially increased by multiplying the number of wires without increasing the number of each."[*]

Not content with these results Professor Henry pushed forward on the line he had thus struck out. He was keenly desirous to ascertain how large a magnetic force he could produce when using only currents of such a degree of smallness as could be transmitted through the comparatively thin copper wires, such as bell-hangers use. During the year 1830 he made great progress in this direction, as the following extracts show:—

"In order to determine to what extent the coil could be applied in developing magnetism in soft iron, and also to ascertain, if possible, the most proper length of the wires to be used, a series of experiments was instituted jointly by Dr. Philip Ten Eyck and myself. For this purpose 1,060 feet (a little more than one-fifth of a mile) of copper wire of the kind called bell-wire, ·045 of an inch in diameter, were stretched several times across the large room of the Academy.

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[*] Sturgeon's "Scientific Researches," p. 188.

[†] Silliman's "American Journal of Science," January, 1831, xix., p. 400.

[*] "Scientific Writings of Joseph Henry," p. 39.

"*Experiment* 1.—A galvanic current from a single pair of plates of copper and zinc two inches square was passed through the whole length of the wire, and the effect on a galvanometer noted. From the mean of several observations, the deflection of the needle was 15°.

"*Experiment* 2.—A current from the same plates was passed through half the above length, or 530 feet of wire; the deflection in this instance was 21°.

By a reference to a trigonometrical table, it will be seen that the natural tangents of 15° and 21° are very nearly in the ratio of the square roots of 1 and 2, or of the relative lengths of the wires in these two experiments.

"The length of the wire forming the galvanometer may be neglected, as it was only 8 feet long.

"*Experiment* 3.—The galvanometer was now removed, and the whole length of the wire attached to the ends of the wire of a small soft iron horse-shoe a quarter of an inch in diameter, and wound with about 8 feet of copper wire with a galvanic current from the plates used in Experiments 1 and 2. The magnetism was scarcely observable in the horse-shoe.

"*Experiment* 4.—The small plates were removed, and a battery composed of a piece of zinc plate 4 inches by 7 inches, surrounded with copper, was substituted. When this was attached immediately to the ends of the 8 feet of wire wound round the horse-shoe, the weight lifted was 4½ lbs.; when the current was passed through the whole length of wire (1,060 feet), it lifted about half an ounce.

"*Experiment* 5.—The current was passed through half the length of wire (530 feet) with the same battery; it then lifted two ounces.

"*Experiment* 6.—Two wires of the same length as in the last experiment were used, so as to form two strands from the zinc and copper of the battery; in this case the weight lifted was four ounces.

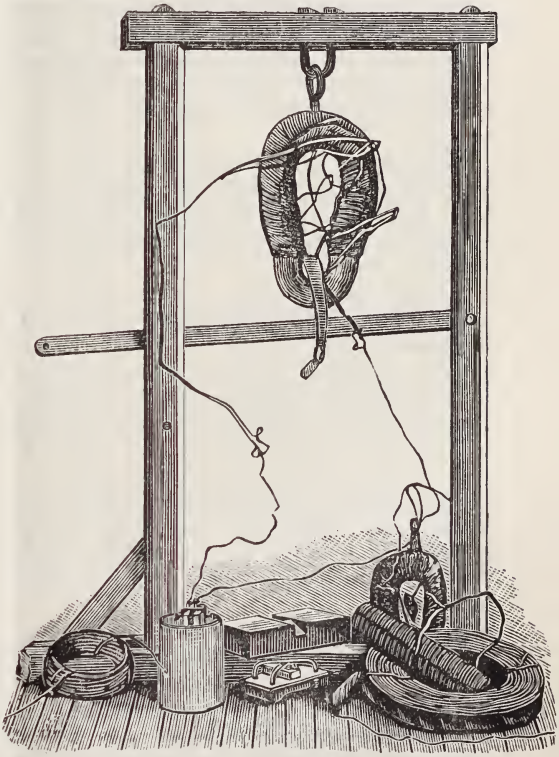
"*Experiment* 7.—The whole length of the wire was attached to a small trough on Mr. Cruickshanks' plan, containing 25 double plates, and presenting exactly the same extent of zinc surface to the action of the acid, as the battery used in the last experiment. The weight lifted in this case was 8 oz.; when the intervening wire was removed, and the trough attached directly to the ends of the wire surrounding the horse-shoe, it lifted only 7 oz. ....

"It is possible that the different states of the trough, with respect to dryness, may have exerted some influence on this remarkable result; but that the effect of a current from a trough, if not increased, is but slightly diminished in passing through a long wire is certain.................................

"But be this as it may, the fact that the magnetic action of a current from a trough is, at least, not sensibly diminished by passing through a long wire is directly applicable to Mr. Barlow's project of forming an electro-magnetic telegraph; and it is also of material consequence in the construction of the galvanic coil. From these experiments it is evident that in forming the coil we may either use one very long wire or several shorter ones, as the circumstances may require; in the first case, our galvanic combinations must consist of a number of plates, so as to give "projectile force;" in the second it must be formed of a single pair.

"In order to test on a large scale the truth of these preliminary results, a bar of soft iron, 2 inches square and 20 inches long, was bent into the form of a horse-shoe, 9½ inches high; the sharp edges of the bar were first a little rounded by the hammer, it weighed 21 lbs.; a piece of iron from the same bar, weighing 7 lbs., was filed perfectly flat on one surface, for an armature or lifter; the extremities of the legs of the horse-shoe were also truly ground to the surface of the armature: around this horse-shoe 540 feet of copper bell-wire were wound in 9 coils of 60 feet each;

FIG. 5.



HENRY'S ELECTROMAGNET.

This Figure, copied from the *Scientific American*, December 11, 1880, represents Henry's electromagnet, still preserved in Princeton College. The other apparatus at the foot, including a current-reverser, and the ribbon-coil used in the famous experiments on secondary and tertiary currents, were mostly constructed by Henry's own hands.

these coils were not continued around the whole length of the bar, but each strand of wire according to the principle before mentioned, occupied about two inches, and was coiled several times backward and forward over itself; the several ends of the wires were left projecting and all numbered, so that the first and last end of each strand might be readily distinguished. In this manner we formed an experimental magnet on a large scale, with which several combinations of wire could be made by merely uniting the different projecting ends. Thus if the second end of the first wire be soldred to the first end of the second wire, and so on through all the series, the whole will form a continued coil of one long wire.

"By soldering different ends the whole may be formed into a double coil of half the length, or into a triple coil of one-third the length, &c. The horse-shoe was suspended in a strong rectangular wooden frame, three feet nine inches high and twenty inches wide, an iron bar was fixed below the magnet, so as to act as a lever of the second order; the different weights supported were estimated by a sliding weight in the same manner as with a common steel-yard (see sketch). In the experiments immediately following (all weights being avoirdupois) a small single battery was used, consisting of two concentric copper cylinders with zinc between them; the whole amount of zinc surface exposed to the acid from both sides of the zinc was 2-5th of a square foot; the battery required only half a pint of dilute acid for its submersion.

"*Experiment* 8.—Each wire of the horse-shoe was soldered to the battery in succession, one at a time; the magnetism developed by each was just sufficient to support the weight of the armature, weighing 7 lbs.

"*Experiment* 9.—Two wires, one on each side of the arch of the horse-shoe, were attached; the weight lifted was 145 lbs.

"*Experiment* 10.—With two wires, one from each extremity of the legs, the weight lifted was 200 lbs.

"*Experiment* 11.—With three wires, one from each extremity of the legs and one from the middle of the arch, the weight supported was 300 lbs.

"*Experiment* 12.—With four wires, two from each extremity, the weight lifted was 500 lbs. and the armature; when the acid was removed from the zinc, the magnet continued to support for a few minutes 130 lbs.

"*Experiment* 13.—With six wires the weight supported was 570 lbs.; in all these experiments the wires were soldered to the galvanic element; the convexion in no case was formed with mercury.

"*Experiment* 14.—When all the wires (nine in number) were attached, *the maximum weight lifted was* 650 *lbs.*, and this astonishing result, it must be remembered, was produced by a battery, containing only 2-5ths of a square foot of zinc surface, and requiring only half a pint of dilute acid for its submersion.

"*Experiment* 15.—A small battery, formed with a plate of zinc 12 inches long and 6 inches wide, and surrounded by copper, was substituted for the galvanic elements used in the last experiment; the weight lifted in this case was 750 lbs.

"*Experiment* 16.—In order to ascertain the effect of a very small galvanic element on this large quantity of iron, a pair of plates, exactly one inch square, was attached to all the wires; the weight lifted was 85 lbs.

"The following experiments were made with wires of different lengths on the same horse-shoe.

"*Experiment* 17.—With 6 wires, each 30 feet long, attached to the galvanic element, the weight lifted was 375 lbs.

"*Experiment* 18.—The same wires used in last experiment were united so as to form 3 coils of 60 feet each; the weight supported was 290 lbs. This result agrees nearly with that of Experiment 11, though the same individual wires were not used; from this it appears that 6 short wires are more powerful than 3 of double the length.

"*Experiment* 19.—The wires used in Experiment 10, but united so as to form a single coil of 120 feet of wire, lifted 60 lbs.; while in Experiment 10 the weight lifted was 200 lbs.; this is a confirmation of the result in the last experiment..................

"In these experiments a fact was observed which appears somewhat surprising; when the large battery was attached, and the armature touching both poles of the magnet, it was capable of supporting more than 700 lbs., but when only one pole is in contact it did not support more than 5 or 6 lbs., and in this case we never succeeded in making it lift the armature (weighing 7 lbs.). This fact may perhaps be common to all large magnets, but we have never seen the circumstance noticed of so great a difference between a single pole and both..................

"A series of experiments was separately instituted by Dr. Ten Eyck, in order to determine the maximum development of magnetism in a small quantity of soft iron.

"Most of the results given in this paper were witnessed by Dr. L. C. Beck, and to this gentleman we are indebted for several suggestions, and particularly that of substituting cotton well waxed for silk thread, which in these investigations became a very considerable item of expense. He also made a number of experiments with iron bonnet-wires, which, being found in commerce already wound, might possibly be substituted in place of copper. The result was that with very short wire the effect was nearly the same as with copper, but in coils of long wire with a small galvanic element it was not found to answer. Dr. Beck also constructed a horse-shoe of round iron 1 inch in diameter, with four coils on the plan before described. With one wire it lifted 30 lbs., with two wires 60 lbs., with three wires 85 lbs., and with four wires 112 lbs.. While we were engaged in these investigations, the last number of the *Edinburgh Journal of Science* was received containing Professor Moll's paper on 'Electro-

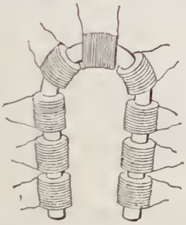
Magnetism.' Some of his results are in a degree similar to those here described; his object, however, was different, it being only to induce strong magnetism on soft iron with a powerful galvanic battery. The principal object in these experiments was to produce the greatest magnetic force with the smallest quantity of galvanism. The only effect Professor Moll's paper has had over these investigations has been to hasten their publication; the principle on which they were instituted was known to us nearly two years since, and at that time exhibited to the Albany Institute."*

In the next number of "Silliman's Journal" (April, 1831), Professor Henry gave "an account of a large electromagnet, made for the laboratory of Yale College." The core of the armature weighed 59½ lbs., it was forged under Henry's own direction, and wound by Dr. Ten Eyck. This magnet, wound with 26 strands of copper bell-wire of total length of 728 feet, and excited by two cells which exposed nearly 4⅞ square feet of surface, readily supported on its armature, which weighed 23 lbs., a load of 2,063 lbs.

Writing in 1867 of his earlier experiments, Henry speaks† thus of his ideas respecting the use of additional coils on the magnet and the increase of battery power:—

"To test these principles on a larger scale, the experimental magnet was constructed, which is shown in Fig. 6. In this a number of compound helices was placed on the same bar, their ends left projecting, and so numbered that they could all be united into one long helix, or variously combined in sets of lesser length.

FIG. 6.



HENRY'S EXPERIMENTAL ELECTROMAGNET.

"From a series of experiments with this and other magnets, it was proved that in order to produce the greatest amount of magnetism from a battery of a single cup a number of helices is required; but when a compound battery is used then one long wire must be employed, making many turns around the iron, the length of wire and consequently the number of turns being commensurate with the projectile power of the battery.

"In describing the results of my experiments the terms 'intensity' and 'quantity' magnets were introduced to avoid circumlocution, and were intended to be used merely in a technical sense. By the intensity magnet I designated a piece of soft iron, so surrounded with wire that its magnetic power could be called into operation by an intensity battery; and by a quantity magnet, a piece of iron so surrounded by a number of separate coils, that its magnetism could be fully developed by a quantity battery.

"I was the first to point out this connection of the two kinds of the battery with the two forms of the magnet, in my paper, in 'Silliman's Journal,' January, 1831, and clearly to state that when magnetism was to be developed by means of a compound battery one long coil must be employed, and when the maximum effect was to be produced by a single battery a number of single strands should be used......Neither the electromagnet of Sturgeon nor any electromagnet ever made previous to my investigations was applicable to transmitting power to a distance........The electromagnet made by Sturgeon, and copied by Dana, of New York, was an imperfect quantity magnet, the feeble power of which was developed by a single battery."

Finally, Henry* sums up his own position as follows:—

"1. Previous to my investigations the means of developing magnetism in soft iron were imperfectly understood, and the electromagnet which then existed was inapplicable to transmissions of power to a distance.

"2. I was the first to prove by actual experiment that in order to develop magnetic power at a distance, a galvanic battery of 'intensity' must be employed to project the current through the long conductor, and that a magnet surrounded by many turns of one long wire must be used to receive this current.

"3. I was the first to actually magnetize a piece of iron at a distance, and to call attention to the fact of the applicability of my experiments to the telegraph.

"4. I was the first to actually sound a bell at a distance by means of the electromagnet.

"5. The principles I had developed were applied by Dr. Gale to render Morse's machine effective at a distance."

Though Henry's researches were published in 1831, they were for some years almost unknown in Europe. Until April, 1837, when Henry himself visited Wheatstone at his laboratory at King's College, the latter did not know how to construct an electromagnet that could be worked through a long wire circuit. Cooke, who became the coadjutor of Wheatstone, had originally come to him to consult him,* in February, 1837, about his telegraph and alarum, the electromagnets of which, though they worked well on short circuits, refused to work when placed in circuit with even a single mile of wire. Wheatstone's own account† of the matter is extremely explicit:—"Relying on my former experience, I at once told Mr. Cooke that his plan would not and could not act as a telegraph, because sufficient attractive power could not be imparted to an electromagnet interposed in a long circuit; and to convince him of the truth of this assertion, I invited him to King's College to see the repetition of the experiments on which my conclusion was founded. He came, and after seeing a variety of voltaic magnets, which even with powerful batteries exhibited only slight adhesive attraction, he expressed his disappointment."

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* Scientific Writings of Joseph Henry, p. 49.

† Statement in Relation to the History of the Electromagnetic Telegraph: from the Smithsonian Annual Report for 1857, p. 99.

* "Scientific Writings of Joseph Henry," vol. ii, p. 435.

After Henry's visit to Wheatstone, the latter altered his tone. He had been using, *faute de mieux*, relay circuits to work the electromagnets of his alarum in a short circuit with a local battery. "These short circuits," he writes, "have lost nearly all their importance and are scarcely worth contending about since *my discovery*" (the italics are our own) "that electromagnets may be so constructed as to produce the required effects by means of the direct current, even in very long circuits."‡

We pass on to the researches of the distinguished physicist of Manchester, whose decease we have lately had to deplore, Mr. J. P. Joule, who, fired by the work of Sturgeon, made most valuable contributions to the subject. Most of these were published either in Sturgeon's "Annals of Electricity," or in the "Proceedings of the Literary and Philosophical Society of Manchester," but their most accessible form is the republished volume issued five years ago by the Physical Society of London.

In his earliest investigations he was endeavouring to work out the details of an electric motor. The following is an extract from his own account ("Reprint of Scientific Papers," p. 7.):—

"In the further prosecution of my inquiries, I took six pieces of round bar iron of different diameters and lengths, also a hollow cylinder, 1-13th of an inch thick in the metal. These were bent in the U-form, so that the shortest distance between the poles of each was half an inch; each was then wound with 10 feet of covered copper wire, 1-40th of an inch in diameter. Their attractive powers under like currents for a straight steel magnet, $1\frac{1}{2}$ inch long, suspended horizontally to the beam of a balance, were, at the distance of half an inch, as follows:—

	No. 1. Hollow.	No. 2. Solid.	No. 3. Solid.	No. 4. Solid.	No. 5. Solid.	No. 6 Solid.	No. 7. Solid.
Length round the bend in inches	6	$5\frac{1}{2}$	$2\frac{2}{3}$	$5\frac{1}{4}$	$2\frac{1}{2}$	$5\frac{1}{4}$	$2\frac{1}{4}$
Diameter in inches	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{1}{4}$	$\frac{1}{4}$
Attraction for steel magnet, in grains	7·5	6·3	5·1	5·0	4·1	4·8	3·6
Weight lifted, in ounces	36	52	92	36	52	20	28

"A steel magnet gave an attractive power of 23 grains, while its lifting-power was not greater than 60 ounces.

"The above results will not appear surprising if we consider, first, the resistance which iron presents to the induction of magnetism, and, second, how very much the induction is exalted by the completion of the magnetic circuit.

"Nothing can be more striking than the difference between the ratios of lifting to attractive power at a distance in the different magnets. Whilst the steel magnet attracts with a force of 23 grains and lifts 60 ounces, the electromagnet No. 3 attracts with a force of only 5·1 grains, but lifts as much as 92 ounces.

"To make a good electromagnet for lifting purposes:—1st. Its iron, if of considerable bulk, should be compound, of good quality, and well annealed. 2nd. The bulk of the iron should bear a much greater ratio to its length than is generally the case. 3rd. The poles should be ground quite true, and fit flatly and accurately to the armature. 4th. The armature should be equal in thickness to the iron of the magnet.

"In studying what form of electromagnet is best for attraction from a distance, two things must be considered, viz., the length of the iron, and its sectional area.

"Now I have always found it disadvantageous to increase the length beyond what is needful for the winding of the covered wire."

These results were announced in March, 1839. In May of the same year Joule propounded a law of the mutual attraction of two electromagnets, as follows:—"The attractive force of two electromagnets for one another is directly proportional to the square of the electric force to which the iron is exposed; or if E denote the electric current, W the length of wire, and M the magnetic attraction,

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* See Mr. Latimer Clark's account of Cooke in vol. viii. of "Journal of Society of Telegraph Engineers," p. 3741, 1880.

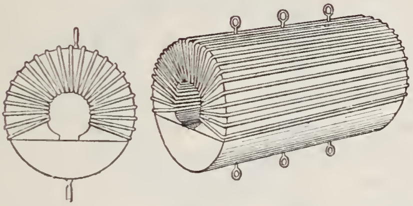
† W. F. Cooke, "The Electric Telegraph: was it invented by Professor Wheatstone?" 1856-7, pt. ii., p. 87.

‡ *Ib.* p. 95.

$M = E^2 W^2$." The discrepancies which he himself observed he rightly attributed to the iron becoming saturated magnetically. In March, 1840, he extended this same law to the lifting power of the horse-shoe electromagnet.

In August, 1840, he wrote to the "Annals of Electricity," on electromagnetic forces, dealing chiefly with some special electromagnets for traction. One of these possessed the form shown in Fig. 7. Both the magnet and the iron keeper were furnished with eye-holes for the purpose of suspension and measurement of the force requisite to detach the keeper. Joule thus writes about the experiments.*

Fig. 7.



Joule's Electromagnet.

> "I proceed now to describe my electromagnets, which I constructed of very different sizes in order to develop any curious circumstance which might present itself. A piece of cylindrical wrought iron, 8 inches long, had a hole one inch in diameter, bored the whole length of its axis; one side was planed until the hole was exposed sufficiently to separate the thus-formed poles one-third of an inch. Another piece of iron, also 8 inches long, was then planed, and being secured with its face in contact with the other planed surface, the whole was turned into a cylinder 8 inches long, 3¾ inches in exterior, and 1 inch interior diameter. The larger piece was then covered with calico and wound with four copper wires covered with silk, each 23 feet long, and 1-11th of an inch in diameter—a quantity just sufficient to hide the exterior surface, and to fill the interior opened hole."........"The above is designated No. 1; and the rest are numbered in the order of their description.
>
> "I made No. 2 of a bar of half-inch round iron 2·7 inches long. It was bent into an almost semicircular shape, and then covered with 7 feet of insulated copper wire, 1-20th of an inch thick. The poles are half-in-inch asunder; and the wire completely fills the space between them.
>
> "A third electromagnet was made of a piece of iron 0·7 inch long, 0·37 inch broad, and 0·15 inch thick. Its edges were reduced to such an extent that the transverse section was elliptical. It was bent into a semicircular shape, and wound with 19 inches of silked copper wire, 1-40th of an inch in diameter.
>
> "To procure a still more extensive variety, I constructed what might, from its extreme minuteness, be termed an *elementary electromagnet.* It is the smallest, I believe, ever made, consisting of a bit of iron wire ¼ of an inch long, and 1-25th of an inch in diometer. It was bent into the shape of a semicircle, and was wound with three turns of *uninsulated* copper wire 1-40th of an inch in thickness."

With these magnets experiments were made with various strengths of currents, the tractive forces being measured by an arrangement of levers. The results, briefly, are as follows:—Electromagnet No. 1, the iron of which weighed 15 pounds, required a weight of 2,090 pounds to detach the keeper. No. 2, the iron of which weighed 1,057 grains, required 49 pounds to detach its armature. No. 3, the iron of which weighed 65·3 grains, supported a load of 12 pounds, or 1,286 times its own weight. No. 4, the weight of which was only half a grain, carried in one instance 1,417 grains, or 2,834 times its own weight.

> "It required much patience to work with an arrangement so minute as this last; and it is probable that I might ultimately have obtained a larger figure than the above, which, however, exhibits a power proportioned to its weight far greater than any on record, and is eleven times that of the celebrated steel magnet which belonged to Sir Isaac Newton.
>
> "It is well known that a steel magnet ought to have a much greater length than breadth or thickness; and Mr. Scoresby has found that when a large number of straight steel magnets are bundled together, the power of each when separated and examined is greatly deteriorated. All this is easily understood, and finds its cause in the attempt of each part of the system to induce upon the other part a contrary magnetism to its own. Still there is no reason why the principle should in all cases be extended from the steel to the electromagnet, since in the latter case a great and commanding inductive power is brought into play to sustain what the former has to support by its own unassisted retentive property. All the preceding experiments support this position; and the following Table gives proof of the obvious and necessary general consequence, the maximum power of the electromagnet is directly proportional to its least transverse sectional area. The second column of the Table contains the least sectional area in square inches of the entire magnetic circuit. The maximum power in pounds avoirdupois is recorded in the third; and this, reduced to an inch square of sectional area, is given in the fourth column under the title of specific power."

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* "Scientific Papers," vol. i, p. 39.

TABLE I.

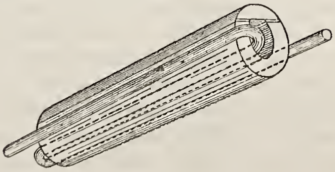
Description.		Least Sectional Area.	Maximum Power.	Specific Power.
My own electromagnets	No. 1....	10	2090	209
	No. 2....	0·196	49	250
	No. 3....	0·0436	12	275
	No. 4...	0·0012	0·202	162
Mr. J. C. Nesbit's. Length round the curve, 3 ft ; diameter of iron core, 2¾ in.; sectional area, 5·7 in.; do. of armature, 4·5 in.; weight of iron, about 50 lbs. ...		4·5	1428	317
Prof. Henry's. Length round the curve, 20 in.; section, 2 in. square; sharp edges rounded off; weight, 21 lbs.		3·94	750	190
Mr. Sturgeon's original. Length round the curve, about 1 ft.; diameter of the round bar, ½ in.		0·196	50	255

"The above examples are, I think, sufficient to prove the rule I have advanced. No. 1 was probably not fully saturated: otherwise I have no doubt that its power per square inch would have approached 300. Also the specific power of No. 4 is small, because of the difficulty of making a good experiment with it."

These experiments were followed by some to ascertain the effect of the length of the iron of the magnet, which he considered, at least in those cases where the degree of magnetization is considerably below the point of saturation, to offer a decidedly proportional resistance to magnetization; a view the justice of which is now after fifty years amply confirmed.

In November of the same year further experiments* in the same direction were published. A tube of iron, spirally made and welded, was prepared, planed down as in the preceding case, and fitted to a similarly prepared armature. The hollow cylinder thus formed, shown in Fig. 8, was 2 feet in length, its internal diameter was 1·42 inch, its internal being 0·5 inch. The least sectional area was 10¼ square inches. The exciting coil consisted of a single copper rod, covered with tape, bent into a sort of S-shape. This was later replaced by a coil of twenty-one copper wires, each 1-25 inch in diameter and 23 feet long, bound together by cotton tape. This magnet, excited by a battery of sixteen of Sturgeon's cast-iron cells, each one foot square and one-and-a-half inch in interior width, arranged in a series of four, gave a lifting power of 2,775 lbs.

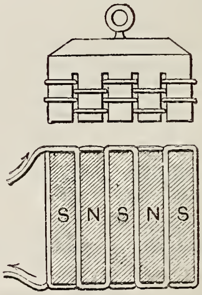
FIG. 8.



JOULE'S CYLINDRICAL ELECTROMAGNET.

Joule's work was well worthy of the master from whom he had learned his first lesson in electromagnetism. He showed his devotion not only by writing descriptions of them for Sturgeon's "Annals," but by exhibiting two of his electromagnets at the Victoria Gallery of Practical Science, of which Sturgeon was director. Others, stimulated into activity by Joule's example, proposed new forms, amongst them being two Manchester gentlemen, Mr. Radford and Mr. Richard Roberts, the latter being a well-known engineer and inventor. Mr. Radford's electromagnet consisted of a flat iron disc, with deep spiral grooves cut in its face, in which were laid the insulated copper wires. The armature consisted of a plain iron disc of similar size. This form is described in Vol. iv. of Sturgeon's "Annals."

FIG. 9.



ROBERTS'S ELECTROMAGNET.

Mr. Roberts's form of electromagnet consisted of a rectangular iron block, having straight parallel grooves cut across its face, as in Fig. 9. This was described in Vol. vi. of Sturgeon's "Annals," p. 166. Its face was 6⅝ inches square, and its thickness 2$\frac{7}{16}$ inch. It weighed, with the conducting wire, 35 lbs.; and the armature, of the same size and 1½ inch thick, weighed 23 lbs. The load sustained by this magnet was no less than 2,950 lbs. Roberts inferred that a magnet, if made of equal thickness, but 5 feet square, would sustain 100 tons' weight. Some of Roberts's apparatus is still preserved in the Museum of Peel Park, Manchester.

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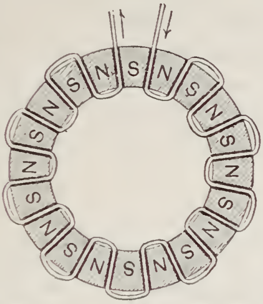
* "Scientific Papers," p. 40, and "Annals of Electricity," vol. v., p. 170.

On p. 431 of the same volume of the "Annals," Joule described yet another form of electromagnet, the form of which resembled in general Fig. 10; but which, in actual fact, was built up of 24 separate flat pieces of iron bolted to a circular brass ring. The armature was a similar structure, but not wound with iron. The iron of the magnet weighed 7 lbs., and that of the armature 4·55 lbs. The weight was 2,710 lbs., when excited by 16 of Sturgeon's cast-iron cells.

FIG. 10.



JOULE'S ZIG-ZAG ELECTROMAGNET.

In a subsequent paper on the calorific effects of magneto-electricity,[*] published in 1843, Joule described another form of electromagnet of horse-shoe shape, made from a piece of boiler-plate. This was not intended to give great lifting power, and was used as the field-magnet of a motor. In 1852, another powerful electromagnet of horse-shoe form, somewhat similar to the preceding, was constructed by Joule for experiment. He came to the conclusion[†] that, owing to magnetic saturation setting in, it was improbable that any force of electric current could give a magnetic attraction greater than 200 lbs. per square inch. "That is, the greatest weight which could be lifted by an electromagnet formed of a bar of iron one inch square, bent into a semi-circular shape, would not exceed 400 lbs."

With the researches of Joule may be said to end the first stage of development. The notion of the magnetic circuit which had thus guided Joule's work did not commend itself at that time to the professors of physical theories; and the practical men, the telegraph engineers, were for the most part content to work by purely empirical methods. Between the practical man and the theoretical man there was, at least on this topic, a great gulf fixed. The theoretical man, arguing as though magnetism consisted in a surface distribution of polarity, and as though the laws of electromagnets were like those of steel magnets, laid down rules not applicable to the cases which occur in practice, and which hindered rather than helped progress. The practical man, finding no help from theory, threw it on one side as misleading and useless. It is true that a few workers made careful observations and formulated into rules the results of their investigations. Amongst these, the principal were Ritchie, Robinson, Müller, Dub, Von Kolke, and Du Moncel; but their work was little known beyond the pages of the scientific journals wherein their results were described. Some of these results will be examined in my later lectures, but they cannot be discussed in this historical *résumé*, which is accordingly closed.

(To be continued.)

Miscellaneous.

SUGAR AND THE SUGAR-CANE IN CUBA.

M. Truy, French Consul at Santiago de Cuba, says that the cultivation of the sugar-cane in the eastern portion of the island of Cuba is almost entirely confined to the districts of Santiago, Guantanamo, and Manzanillo. This cultivation, although it has experienced some extension of late years, is not in the flourishing condition it was twenty years ago. This falling off is due to the civil war, which ruined many planters and discouraged others. The profits, however, realised for some time past by those planters who had sufficient credit, or confidence in the future, to continue to engage in this industry have given a stimulus to the cultivation of the cane. Sugar factories have been established in many parts, particularly in the district of Guantanamo and Manzanillo; old sugar factories have been supplied with fresh plant, and many planters, encouraged by the high prices recently realised, have hastened to get their ground ready for cultivation. Part of the products of the province of Santiago is shipped to Spain, and some small quantity is consigned each year to Canada, but the United States absorbs almost the whole of the yield of the island. The Cuba market was some years ago controlled by French merchants, who owned the greater part of the sugar factories of the province, but since the civil war many planters sold their estates and retired to France. A few estates however are still owned by Frenchmen, at Guantanamo especially; those known as Sainte Marie, Sainte Cecile, and San Antonio are directed or owned by Frenchmen. All the land in the island is in general fit for the cultivation of the cane, an even surface being generally chosen with a view to facilitate the working and the harvesting. The ground should also be as near the sea as possible, so as to avoid the cost of carriage and transport, which is particularly high in that part of the island, where it may be said there is an absence of railroads, and the carriage roads are in a deplorable condition. If the ground chosen is one that has hitherto been uncultivated, the planter first of all clears it in cutting down the branches of the trees and small shrubs with the *machete*, and burning the larger trees. The expenses of these preliminary operations may be estimated at from 400 to 500 dollars per plantation of thirteen hectares (the hectare is equivalent to 2·47 acres). Holes are then dug at intervals of from three to four feet, and in them are placed horizontally pieces of cane of a length from two to three joints. If the ground has previously been under cultivation the methods differ. The ground must first of all be ploughed, and furrows are then made in which entire canes are stretched *à chorros*, that is to say, end to end horizontally; the plants are then covered with earth. The sugar-cane is frequently planted in the spring, but many planters are of opinion that plantations in Cuba sown in winter give a much better yield. The young plants are allowed to shoot for ten or eleven months if they have been planted in the spring, for fourteen or sixteen months if planted in the winter, and the harvest then takes place. There are in the island several varieties of sugar-cane—the white or Otaheite cane, the twisted white cane, the twisted violet cane, and the so-called black cane. The first two varieties are the only ones cultivated at Cuba. The white cane is prepared for planting in virgin soil, and gives a good yield. The crystalline is reserved for old plantations; it is better adapted to resist the long drought than the white variety. The cultivation of the three last species of sugar-canes has been abandoned on account of their insufficient yield. Before the abolition of slavery, the planters themselves cultivated their fields; since that period, however, they have experienced the greatest difficulty in obtaining a sufficient number of hands to harvest their canes. Many planters in consequence deemed it advisable to divide their labour between a certain number of colonists, who are bound to cultivate each his plot of ground, to plant the canes, to cut them at harvest time, and to carry them to the factory, where they receive after the sugar is turned out a certain proportion of the quantity of the sugar extracted from the canes harvested on their allotments. Cuban sugar is generally prepared for export; the special quality intended for consumption is clearer and finer than that shipped abroad.

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[*] "Scientific Papers," vol. i, p. 123; and "Phil. Mag.," Ser. 3, vol. xxiii., p. 263, 1843.

[†] "Scientific Papers," vol. i., p. 362; and "Phil. Mag.," Ser. 4, vol. iii, p. 32.

BRITISH-GROWN TEA.

The following statistics respecting the increase in the consumption of British-grown teas are taken from a late circular of Messrs. Gow, Wilson, and Stanton, tea brokers. The home consumption (in lbs.) between the years 1864 and 1889 inclusive was:—

Year.	China, &c.	Indian.	Ceylon.	Total.
1864.........	85,799,235	2,800,000	—	88,599,235
1869.........	101,080,491	10,716,000	—	111,796,491
1874.........	118,751,000	18,528,000	—	137,279,000
1879.........	126,340,000	34,092,000	—	160,432,000
1884.........	110,843,000	62,717,000	1,500,000	175,060,000
1889.........	61,100,000	96,028,491	28,500,000	185,628,491

In 1889 the quantity of China tea used in Great Britain was less than the home consumption in 1854—35 years previously. In 1889 the quantity of British-grown tea used was more than double the entire home consumption in the same year, 1854. In 1889 the quantity of British-grown tea used was in excess of the entire home consumption in 1871—18 years previously.

A further increase in the use of British-grown tea is shown by the returns of the first six months of 1890. The per-centage per head in 1881 was 35 for China tea, 51 for Indian, and 14 for Ceylon. In 1890, Indian and Ceylon tea showed an increase respectively to 54 and 16, and China tea decreased to 30. The quantity of tea of all kinds used annually per head of population, which was 1·81 lbs. in 1849, had risen to 4·91 lbs. in 1889.

Since the 1st January, the exports from Great Britain of Indian and Ceylon teas have been shown separately from those of China tea in the official figures, and it appears that 1,445,994 lbs. of Indian tea, and 651,968 lbs. of Ceylon tea were exported from Great Britain during the six months ending 30th June.

The exports were distributed as follows:—

	Indian.	Ceylon.
	lbs.	lbs.
United States of America	423,776	189,636
Canada	235,595	96,203
Turkey	256,634	3,121
Holland	173,414	85,234
*Germany	47,391	121,842
Russia	15,664	6,943
France	22,172	9,040
Other places	269,348	139,949
	1,443,994	651,968

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* Probably part of the tea exported to Germany was to Russia.

Journal of the Society of Arts.

No. 1,973. Vol. XXXVIII.

FRIDAY, SEPTEMBER 12, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

EXAMINATIONS, 1891.

The subjects of examination are—1. Arithmetic; 2. English (including composition and correspondence, and précis writing); 3. Book-keeping; 4. Commercial Geography; 5. Shorthand; 6. Type-writing; 7. French; 8. German; 9. Italian; 10. Spanish; 11. Portuguese; 12. Russian; 13. Danish; 14. Chinese; 15. Japanese; 16. Political Economy; 17. Domestic Economy; 18. Theory of Music; 19. Practice of Music.

These examinations will be held on March 16, 17, 18, and 19, with the exception of that in the Practice of Music, which will be held during the week commencing on the 1st of June.

In addition to the syllabus of examinations, the Programme contains an appendix giving the questions set in 1890, and the reports of the examiners on the papers worked.

The Programme is now ready. Copies can be obtained gratis on application to the Secretary.

BROWNING TABLET.

A memorial tablet to Robert Browning has been erected on the house, No. 19, Warwick-crescent, Maida-hill, where the poet lived from the time of his return from Italy after the death of his wife, in 1861, until the summer of 1887, when he removed to 29, De Vere-gardens.

Proceedings of the Society.

CANTOR LECTURES.

THE ELECTROMAGNET.

By Professor Silvanus P. Thompson,
D.Sc., B.A., M.I.E.E.

Lecture I.—Delivered January 20th, 1890.

(*Continued from p.* 875.)

Generalities concerning Electromagnets.

Materials.—In any complete treatise on the electromagnet it would be needful to enumerate, and to discuss in detail, the several constructive features of the apparatus. Three classes of material enter into its construction; first, the iron which constitutes the material of the magnetic circuit, including the armature as well as the cores on which the coils are wound, and the yoke that connects them; secondly, the copper which is employed as the material which conducts the electric currents, and which is usually in the form of wire; thirdly, the insulating material employed to prevent the copper coils from coming into contact with one another, or with the iron core. There is a further subject for discussion in the bobbins, formers, or frames upon which the coils are in so many cases wound, and which may in some cases be made in metal, but often are not. The engineering of the electromagnet might well furnish matter for a special chapter.

Typical Forms.

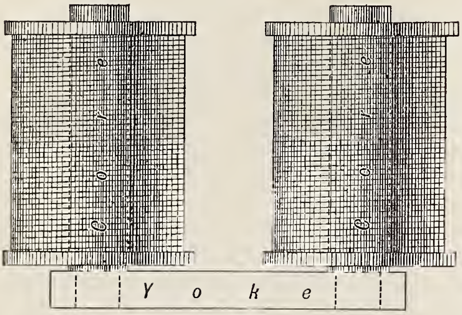
It is difficult to devise a satisfactory or exhaustive classification of the varied forms which the electromagnet has assumed; but it is at least possible to enumerate some of the typical forms.

1. *Bar Electromagnet.*—This consists of a single straight core (whether solid, tubular, or laminated), surrounded by a coil. Fig. 3 (p. 865) depicted Sturgeon's earliest example.

2. *Horse-shoe Electromagnet.*—There are two sub-types included in this name. The original electromagnet of Sturgeon (Fig. 1, p. 865) really resembled a horse-shoe in form, being constructed of a single piece of round wrought iron, about half an inch in diameter, and nearly a foot long, bent into an arch. In

recent years the other sub-type has prevailed, consisting, as shown in Fig. 11, of two separate iron cores, usually cut from circular rod, fixed into a third piece of wrought iron, the yoke. Occasionally this form is modified by the use of one coil only, the second core being left uncovered. This form has received in France the name of *aimant boîteux*. Its merits will be considered later. Sometimes a single coil is wound upon the yoke, the two limbs being uncovered.

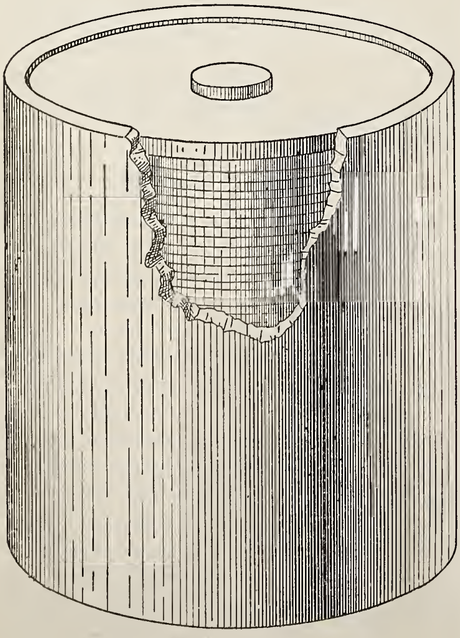
FIG. 11.



TYPICAL TWO-POLE ELECTROMAGNET.

3. *Iron-clad Electromagnet.*—This form, which has many times been re-invented, differs from the simple bar magnet in having an iron shell or casing external to the coils, and attached to the core at one end. Such a magnet presents, as depicted in Fig. 12, a central pole at one end surrounded by an outer annular pole of the opposite polarity. The appropriate armature for electromagnets of this type is a circular disk or lid of iron.

FIG. 12.



IRON-CLAD ELECTROMAGNET

4. *Coil-and-Plunger.*—A detached iron core is attracted into a hollow coil, or solenoid, of copper wire, when a current of electricity flows round the latter. This is a special form, and will receive extended consideration.

5. *Special Forms.*—Beside the leading forms enumerated above, there are a number of special types, multipolar, spiral, and others designed for particular purposes. There is also a group of forms intermediate between the ordinary electromagnet and the coil-and-plunger form.

POLARITY.

It is a familiar fact that the polarity of an electromagnet depends upon the sense in which the current is flowing around it. Various rules for remembering the relation of the electric flow and the magnetic force have been given. One of them that is useful is that when one is looking at the north pole of an electromagnet, the current will be flowing around that pole in the sense opposite to that in which the hands of a clock are seen to revolve. Another useful rule, suggested by Maxwell, is illustrated by Fig. 13, namely, that the sense of the circulation of the current (whether right or left-handed), and the positive direction of the resulting magnetic force are related together in the same way as the rotation and the travel of a right-handed screw are associated together. Right-handed rotation of the screw is associated with forward travel. Right-handed circulation of a current is associated with a magnetic force tending to produce north polarity at the forward end of the core.

FIG. 13.

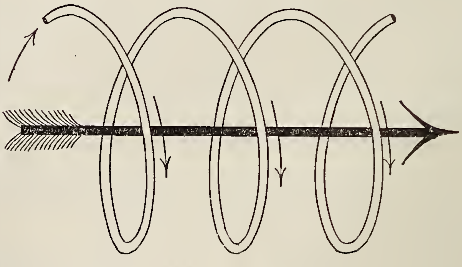


DIAGRAM ILLUSTRATING RELATION OF MAGNETIZING CIRCUIT AND RESULTING MAGNETIC FORCE.

Uses in General.

Regarded as a piece of mechanism, an electromagnet may be regarded as an apparatus for producing a mechanical action at a place distant from the operator who controls it; the means of communication from the operator to the distant point where the electromagnet is being the electric wire. The uses of electromagnets may, however, be divided into two main divisions. For certain purposes an electromagnet is required merely for obtaining temporary adhesion or lifting power. It attaches itself to an armature, and cannot be detached so long as the exciting current is maintained, except by the application of a superior opposing pull. The force which an electromagnet thus exerts upon an armature of iron, with which it is in direct contact, is always considerably greater than the force with which it can act on an armature at some distance away, and the two cases must be carefully distinguished. *Traction* of an armature in contact, and *attraction* of an armature at a distance, are two different functions. So different, indeed, that it is no exaggeration to say that an electromagnet designed for the one purpose is unfitted for the other. The question of designing electromagnets for either of these purposes will occupy a large part of these lectures. The action which an electromagnet exercises on an armature in its neighbourhood may be of several kinds. If the armature is of soft iron, placed nearly parallel to the polar surfaces, the action is one simply of attraction, producing a motion of pure translation, irrespective of the polarity of the magnet. If the armature lies oblique to the line of the poles there will be a tendency to turn it round, as well as to attract it; but, again, if the armature is of soft iron the action will be independent of the polarity of the magnet, that is to say, independent of the direction of the exciting current. If, however, the armature be itself a magnet of steel permanently magnetized, then the direction in which it tends to turn, and the amount, or even the sign of the force with which it is attracted, will depend on the polarity of the electromagnet, that is to say, will depend on the direction in which the exciting current circulates. Hence there arises a difference between the operation of a *non-polarised* and that of a *polarised* apparatus, the latter term being applied to those forms in which there is employed a portion—say an armature—to which an initial fixed magnetization has been imparted. Non-polarised apparatus is in all cases independent of the direction of the current. Another class of uses served by electromagnets is the production of rapid vibrations. These are employed in the mechanism of electric trembling bells, in the automatic breaks of induction coils, in electrically-driven tuning-forks such as are employed for chronographic purposes, and in the instruments used in harmonic telegraphy. Special constructions of electromagnet are appropriate to special purposes such as these. The adaptation of electromagnets for the special end of responding to rapidly alternating currents is a closely kindred matter. Lastly, there are certain applications of the electromagnet, notably in the construction of some forms of arc lamp, for which it is specially sought to obtain an equal, or approximately equal, pull over a definite range of motion. This use necessitates special designs.

The Properties of Iron.

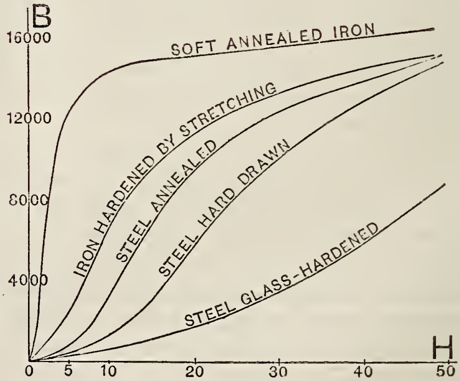
A knowledge of the magnetic properties of iron of different kinds is absolutely fundamental to the theory and design of electromagnets. No excuse is therefore necessary for treating this matter with some fulness. In all modern treatises of magnetism the usual terms are defined and explained. Magnetism which was formerly treated of as though it were something distributed over the end-surfaces of magnets, is now known to be a phenomenon of internal structure; and the appropriate mode of considering it is to treat the magnetic materials, iron and the like, as being capable of acting as good conductors of the magnetic lines; in other words, as possessing magnetic *permeability*. The precise notion now attached to this word is that of a numerical coefficient. Suppose a magnetic force—due, let us say, to the circulation of an electric current in a surrounding coil—were to act on a space occupied by air; there would result a certain number of magnetic lines in that space. In fact, the intensity of the magnetic force, symbolised by the letter H, is often expressed by saying that it would produce H magnetic lines per square centimetre in air. Now, owing to the superior magnetic power of iron, if the space subjected to this magnetic force were filled with iron instead of air, there would be produced a larger number of magnetic lines per square centimetre. This larger number in the iron expresses the degree of magnetization in the iron; it is symbolized* by the letter **B**. The ratio of **B** to **H** expresses the permeability of the material. The usual symbol for permeability is the Greek letter μ. So we may say that **B** is equal to μ times **H**. For example, a certain specimen of iron, when subjected to a magnetic force capable of creating, in air, 50 magnetic lines to the square centimetre, was found to be permeated by no fewer than 16,062 magnetic lines per square centimetre. Dividing the latter figure by the former, gives as the value of the permeability at this stage of the magnetization 321, or the permeability of the iron is 321 times that of air. The permeability of such non-magnetic materials as silk, cotton, and other insulators, also of brass, copper, and all the non-magnetic metals is taken as 1; being practically the same as that of the air.

This mode of expressing the facts is, however, complicated by the fact of the tendency in all kinds of iron to magnetic saturation. In all kinds of iron the magnetizability of the material becomes diminished as the actual magnetization is pushed further. In other words, when a piece of iron has been magnetized up to a certain degree it becomes, from that degree onward, less permeable to further magnetization, and, though actual saturation is never reached, there is a practical limit beyond which the magnetization cannot well be pushed. Joule was one of the first to establish this tendency toward magnetic saturation. Modern researches have shown numerically how the permeability diminishes as the magnetization is pushed to higher stages. The practical limit of the magnetization, **B**, in good wrought iron is about 20,000 magnetic lines to the square centimetre, or about 125,000 lines to the square inch; and, in cast iron the practical saturation limit is nearly 12,000 lines per square centimetre, or about 70,000 lines per square inch.

In designing electromagnets, before calculations can be made as to the size of a piece of iron required for the core of a magnet for any particular purpose, it is necessary to know the magnetic properties of that piece of iron; for it is obvious that if the iron be of inferior magnetic permeability, a larger piece of it will be required in order to produce the same magnetic effect as might be produced with a smaller piece of higher permeability. Or, again, the piece having inferior permeability will require to have more copper wire wound on it; for in order to bring up its magnetization to the required point, it must be subjected to higher magnetizing forces than would be necessary if a piece of higher permeability had been selected.

A convenient mode of studying the magnetic facts respecting any particular brand of iron is to plot on a diagram the curve of magnetization—*i.e.*, the curve in which the values, plotted horizontally, represent the magnetic force, **H**, and the values plotted vertically those that correspond to the respective magnetization, **B**. In Fig. 14, which is modified from the researches of Professor Ewing, are given five curves relating to soft iron, hardened iron, annealed steel, hard-drawn steel, and glass-hard steel. It will be noticed that all these curves have the same general form. For small values of **H** the values of **B** are small, and as **H** is increased **B** increases also. Further, the curve rises very suddenly, at least with all the softer sorts of iron, and then bends over and becomes nearly horizontal. When the magnetization is in the stage below the bend of the curve, the iron is said to be far from the state of

Fig. 14.



Curves of Magnetization of different Magnetic Materials.

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* The following are the various ways of expressing the three quantities under consideration:—

B—The internal magnetization.
The magnetic induction.
The induction.
The intensity of the induction.
The permeation.
The number of lines per square centimetre in the material.

H—The magnetizing force at a point.
The magnetic force at a point.
The intensity of the magnetic force.
The number of lines per square centimetre that there would be in air.

μ—The magnetic permeability.
The permeability.
The specific conductivity for magnetic lines.
The magnetic multiplying power of the material.

saturation. But when the magnetization has been pushed beyond the bend of the curve, the iron is said to be in the stage approaching saturation; because at this stage of magnetization it requires a large increase in the magnetizing force to produce even a very small increase in the magnetization. It will be noted that for soft wrought iron the stage of approaching saturation sets in when $\mathbf{B}$ has attained the value of about 16,000 lines per square centimetre, or when $\mathbf{H}$ has been raised to the value of about 50. As we shall see, it is not economical to push $\mathbf{B}$ beyond this limit; or, in other words, it does not pay to use stronger magnetic forces than those of about $\mathbf{H} = 50$.

METHODS OF MEASURING PERMEABILITY.

There are four sorts of experimental methods of measuring permeability.

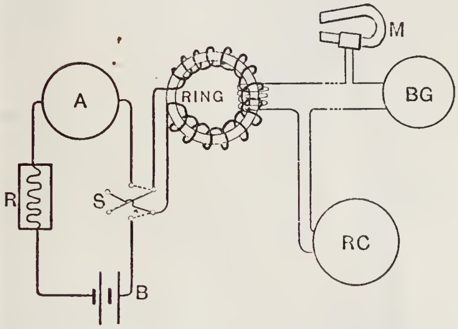
1. *Magnetometric Methods.*—These are due to Müller, and consist in surrounding a bar of the iron in question by a magnetizing coil, and observing the deflection its magnetization produces in a magnetometer.

2. *Balance Methods.*—These methods are a variety of the preceding, a compensating magnet being employed to balance the effect produced by the magnetized iron on the magnetometric needle. Von Feilitzsch used this method, and it has received a more definite application in the magnetic balance of Professor Hughes. The actual balance is exhibited to-night upon the table, and I have beside me a large number of observations made by students of the Technical College by its means, upon sundry samples of iron and steel. None of these methods are, however, to be compared with those that follow.

3. *Inductive Methods.*—There are several varieties of these, but all depend on the generation of a transient induction-current in an exploring coil which surrounds the specimen of iron, the integral current being proportional to the number of magnetic lines introduced into, or withdrawn from, the circuit of the exploring coil. Three varieties may be mentioned.

(*A*) *Ring Method.*—In this method, due to Kirchhoff, the iron under examination is made up into a ring, which is wound with a primary, or exciting coil, and with a secondary, or exploring coil. Determinations on this plan have been made by Stowletow, Rowland, Bosanquet, and Ewing; also by Hopkinson. Rowland's arrangement of the experiment is shown in Fig. 15, in which B is the exciting battery; S, the switch for turning on or reversing the current; R, an adjustable resistance; A, an ampere-metre; and BG the ballistic galvanometer, the first swing of which measures the integral induced current. RC is an earth-inductor or reversing coil wherewith to calibrate the readings of the galvanometer; and above is an arrangement of a coil and a magnet to assist in bringing the swinging needle to rest between the observations. The exciting coil and the exploring coil are both wound upon the ring; the former is distinguished by being drawn with a thicker line. The usual mode of procedure is to begin with a feeble exciting current, which is suddenly reversed, and then reversed back. The current is then increased, reversed, and re-reversed; and so on, until the strongest available points are reached. The values of the magnetizing force $\mathbf{H}$ are calculated from the observed value of the current by the following rule. If the strength of the current, as measured by the ampere-meter, be i, the number of spires of the exciting coil S, and the length, in centimetres, of the coil (*i.e.*, the mean circumference of the ring) be l, then $\mathbf{H}$ is given by the formula—

FIG. 15.

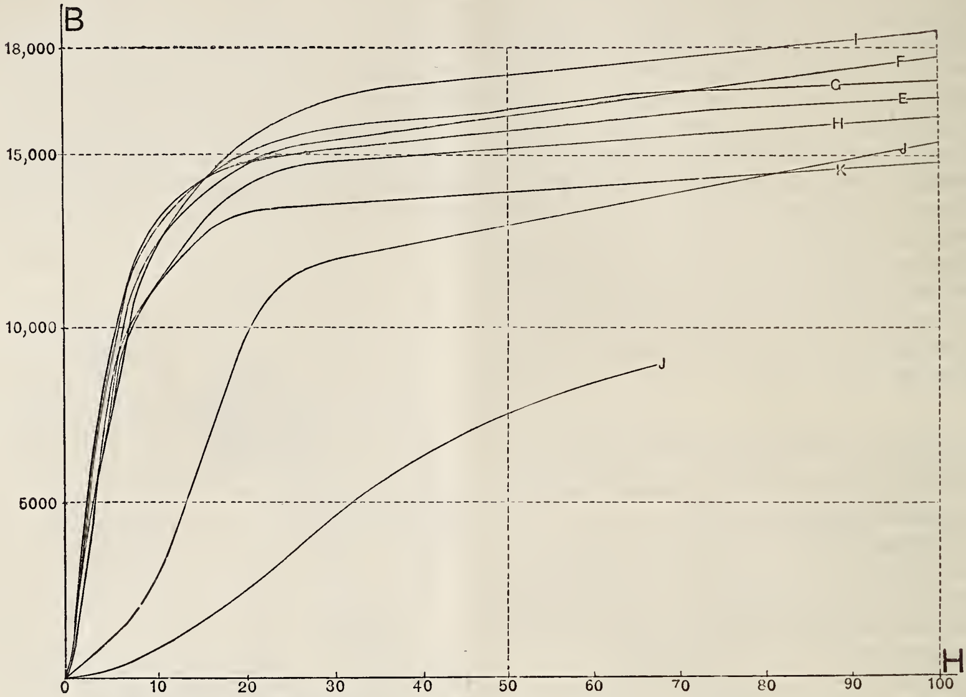


RING METHOD OF MEASURING PERMEABILITY (ROWLAND'S ARRANGEMENT).

$$\mathbf{H} = \frac{4\pi}{10} \times \frac{Si}{l} = 1{\cdot}2566 \times \frac{Si}{l}$$

Bosanquet, applying this method to a number of iron rings, obtained some important results. In Fig. 16 (p. 882) are plotted out the values of $\mathbf{H}$ and $\mathbf{B}$ for seven rings. One of these, marked J, was of cast steel, and was examined both when soft and afterwards when hardened.

FIG. 16.



BOSANQUET'S DATA OF MAGNETIC PROPERTIES OF IRON AND STEEL RINGS.

Another, marked I, was of the best Lowmoor iron. Five were of Crown iron, of different sizes. They were marked for distinction with the letters G, E, F, H, K. In the accompanying Table are set down the values of **B** at different stages of the magnetization.

TABLE OF VALUES OF **B** IN FIVE CROWN IRON RINGS.

Name.	G.	E.	F.	H.	K.
Mean Diam. Bar thickness.	21·5 cm. 2·535	10·035 cm. 1·298	22 1 cm. 1·292	10·735 cm. 0·7137	22·725 cm. 0·7544
Magnetising Force.					
0·2	126	73	62	82	85
0·5	377	270	224	208	214
1	1,449	1,293	840	675	885
2	4,564	3·952	3,533	2,777	2,417
5	9,900	9,147	8,293	8,479	8,884
10	13,023	13,357	12,540	11,376	11,388
20	14,911	14,653	14,710	14,066	13,273
50	16,217	15,704	16,062	15,174	13,890
100	17,148	16,677	17,900	16,134	14,837

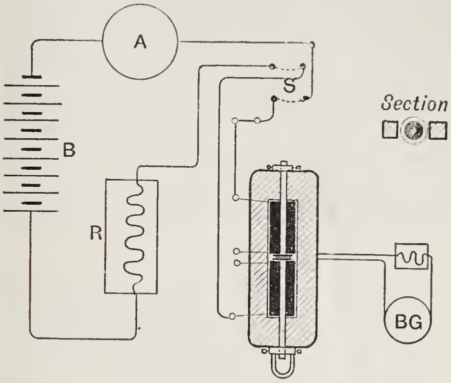
I have the means here of illustrating the induction-method of measuring permeability. Here is an iron ring, having a cross section of almost exactly one square centimetre. It is wound with an exciting coil supplied with current by two accumulator cells; over it is also wound an exploring coil of 100 turns connected in circuit (as in Rowland's arrangement) with a ballistic galvanometer which reflects a spot of light upon yonder screen. In the circuit of the galvanometer is also included a reversing earth-coil. As a matter of fact this earth-coil is of such a size, and wound with so many convolutions of wire, that when it is turned over, the amount of cutting of magnetic lines is equal to 840,000, or is the same as if 840,000 magnetic lines had been cut once. By adjusting the resistance of the galvanometer circuit, it is arranged that the first swing due to the induced current when I suddenly turn over the earth coil is 8·4 scale divisions. Then, seeing that our exploring coil has 100 turns, it follows that when in our subsequent experiment with the ring we get an induced current from it, each division of the scale over which the spot swings will mean 1,000 lines in the iron. I turn on my exciting current. See: it swings about 11 divisions. On breaking the circuit it swings nearly 11 divisions the other way. That means that the magnetizing force carries the magnetization of the iron up to 11,000 lines; or, as the cross-section is about 1 square centimetre, **B** = 11,000. Now, how much is **H**? The exciting coil has 180 windings, and the exciting current through the amperemeter is just 1 ampere. The total excitation is just 180 "ampere-turns." We must, according to our rule given above, multiply this by 1·2566 and divide by the mean circumferential length of the coil, which is about 32 centimetres. This makes **H** = 7. So if **B** = 11,000 and **H** = 7, the permeability (which is the ratio of them) is about 1,570. It is a rough and hasty experiment, but it illustrates the method.

Bosanquet's experiments settle the debated question whether the outer layers of an iron core shield the inner layers from the influence of magnetizing forces. Were this the case, the rings made from thin bar iron should exhibit higher values of B than do the thicker rings. This is not so; for the thickest ring, G, shows throughout the highest magnetizations.

(*B*) *Bar Method.*—This method consists in employing a long bar of iron instead of a ring. It is covered from end to end with the exciting coil, but the exploring coil consists of but a few turns of wire situated just over the middle part of the bar. Rowland, Bosanquet, and Ewing have all employed this variety of method; and Ewing specially used bars the length of which was more than 100 times their diameter, in order to get rid of errors arising from end-effects.

(*C*) *Divided Bar Method.*—This method, due to Dr. Hopkinson,* is illustrated by Fig. 17. The apparatus consists of a block of annealed wrought iron about 18 inches long, 6½ wide, 2 deep, out of the middle of which is cut out a rectangular space to receive the magnetising coils.

FIG. 17.



HOPKINSON'S DIVIDED BAR METHOD OF MEASURING MAGNETIC PERMEABILITY.

The test samples of iron consist of two rods, each 12·65 millimetres in diameter, turned carefully true, and slide in through holes bored in the ends of the iron blocks. These two rods meet in the middle, their ends being faced true so as to make a good contact. One of them is secured firmly, and the other has a handle fixed to it, by means of which it can be withdrawn. The two large magnetizing coils do not meet, a space being left between them. Into this space is introduced the little exploring coil, wound upon an ivory bobbin, through the eye of which passes the end of the movable rod. The exploring coil is connected to the ballistic galvanometer, BG, and is attached to an india-rubber spring (not shown in the Fig.), which, when the rod is suddenly pulled back, causes it to leap entirely out of the magnetic field. The exploring coil had 350 turns of fine wire; the two magnetizing coils had 2,008 effective turns. The magnetizing current, generated by a battery, B, of eight Grove cells, was regulated by a variable liquid resistance, R, and by a shunt resistance. A reversing switch and an amperemeter, A, were included in the magnetizing circuit. By means of this apparatus the sample rods to be experimented upon could be submitted to any magnetizing forces, small or large, and the actual magnetic condition could be examined at any time by breaking the circuit and simultaneously withdrawing the movable rod. This apparatus, therefore, permitted the observation separately of a series of increasing (or decreasing) magnetizations without any intermediate reversals of the entire current. Thirty-five samples of various irons of known chemical composition were examined by Hopkinson, the two most important for present purposes being an annealed wrought iron and a grey cast iron, such as are used by Messrs. Mather and Platt in the construction of dynamo machines. Hopkinson embodied his results in curves, from which it is possible to construct, for purposes of reference, numerical Tables of sufficient accuracy to serve for future calculations. The curves of these two samples of iron are reproduced in Fig. 18, but with one simple modification. British engineers who unfortunately are condemned by local circumstances to use inch measures instead of the international metric system, prefer to have the magnetic facts also stated in terms of square inch units instead of square centimetre units. This change has been made in Fig. 18, and the symbols $B_{''}$ and $H_{''}$ are chosen to indicate the numbers of magnetic lines to the square inch in iron and in air respectively. The permeability, or multiplying power of the iron is the same, of course, in either measure. In Table II. are given the corresponding data in square inch measure; and in Table III. the data in square centimetre measure for the same specimens of iron.

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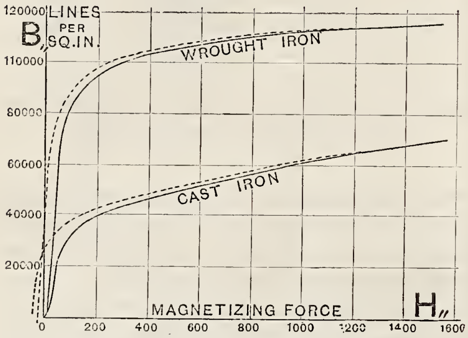
* "Phil. Trans.," 1885, p 564.

FIG. 18.



CURVES OF MAGNETIZATION OF IRON.

It will be noted that Hopkinson's curves are double, there being one curve for the ascending magnetizations, and a separate one, a little above the former, for descending magnetizations. This is a point of a little importance in designing electromagnets. Iron, and particularly hard sorts of iron, and steel, after having been subjected to a high degree of magnetizing force, are subsequently to a lesser magnetizing force found to retain a higher degree of magnetization than if the lower magnetizing force had been simply applied. For example, reference to Fig. 18 shows that the wrought iron, where subjected to a magnetizing force gradually rising from zero to $H_{''}$ = 200, exhibits a magnetization of $B_{''}$ = 95,000; but after $H_{''}$ has been carried up to over 1,000, and then reduced again to 200, $B_{''}$ does not come down again to 95,000, but only to 98,000. Any sample of iron which showed great retentive qualities, or in which the descending curve differs widely from the ascending curve, would be unsuitable for constructing electromagnets, for it is important that there should be as little residual magnetism as possible in the cores. It will be noted that the curves for cast-iron show more of this residual effect than do those for

TABLE II. (Square Inch Units.)

Annealed Wrought Iron.			Grey Cast Iron.		
$B_{''}$	μ	$H_{''}$	$B_{''}$	μ	$H_{''}$
30,000	4,650	6 5	25,000	763	32·7
40,000	3,877	10·3	30,000	756	39·7
50,000	3,031	16·5	40,000	258	155
60,000	2,159	27·8	50,000	114	439
70,000	1,921	36·4	60,000	74	807
80,000	1,409	56·8	70,000	40	1480
90,000	907	99·2	—	—	—
100,000	408	245	—	—	—
110,000	166	664	—	—	—
120,000	75	1581	—	—	—
130,000	35	3714	—	—	—
140,000	27	5185	—	—	—

TABLE III.—(Square Centimetre Units).

Annealed Wrought Iron.			Grey Cast Iron.		
B	μ	H	B	μ	H
5,000	3,000	1·66	4,000	800	5
9,000	2,250	4	5,000	500	10
10,000	2,000	5	6,000	279	21·5
11,000	1,692	6·5	7,000	133	42
12,000	1,412	8·5	8,000	100	80
13,000	1,083	12	9,000	71	127
14,000	823	17	10,000	53	188
15,000	526	28·5	11,000	37	292
16,000	320	50	—	—	—
17,000	161	105	—	—	—
18,000	90	200	—	—	—
19,000	54	350	—	—	—
20,000	30	666	—	—	—

wrought-iron. The numerical data in Tables II. and III. are means between the ascending and descending values.

As an example of the use of the Tables, we may take the following:—How strong must the magnetizing force be in order to produce in wrought-iron a magnetization of 110,000 lines to the square inch? Reference to Table II, or to Fig. 18, shows that a magnetizing field of 664 will be required, and that at this stage of the magnetization the permeability of the iron is only 166. As there are 6·45 square centimetres to the square inch, 110,000 lines to the square inch correspond very nearly to 17,000 lines to the square centimetre; and $\mathbf{H}_{''} = 664$ corresponds very nearly to $\mathbf{H} = 100$.

TRACTION METHODS.

Another group of methods of measuring permeability is based upon the law of magnetic traction. Of these there are several varieties.

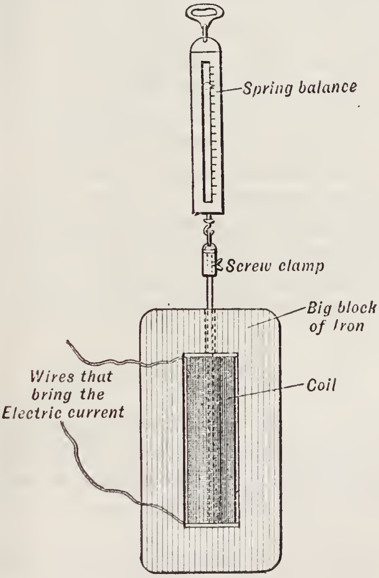
(*D*) *Divided Ring Method.*—Mr. Shelford Bidwell has kindly lent me the apparatus with which he carried out this method. It consists of a ring of very soft charcoal iron rod 6·4 millimetres in thickness, the external diameter being 8 centimetres, sawn into two half rings, and then each half carefully wound over with an exciting coil of insulated copper wire of 1,929 convolutions in total. The two halves fit neatly together; and in this position it constitutes practically a continuous ring. When an exciting current is passed round the coils both halves become magnetized and attract one another. The force required to pull them asunder is then measured. According to the law of traction, which will occupy us in the second lecture, the tractive force (over a given area of contact) is proportional to the square of the number of magnetic lines that pass from one surface to the other through the contact joint. Hence the force of traction may be used to determine **B**; and on calculating **H** as before, we can determine the permeability. The following Table IV. gives a summary of Mr. Bidwell's results.

TABLE IV.—(Square Centimetre Measure).

Soft Charcoal Iron.		
B	μ	**H**
7,390	1899·1	3·9
11,550	1121·4	10·3
15,460	386·4	40
17,330	150·7	115
18,470	88·8	208
19,330	45·3	427
19,820	33·9	585

(*E*) *Divided Rod Method.*—In this method, also used by Mr. Bidwell, an iron rod hooked at both ends was divided across the middle, and placed within a vertical surrounding magnetizing coil. One hook was hung up to an overhead support; to the lower hook was hung a scale-pan. Currents of gradually-increasing strength were sent around the magnetizing coil from a battery of cells, and note was taken of the greatest weight which could in each case be placed in the scale-pan without tearing asunder the ends of the rods.

FIG. 19.



THE PERMEAMETER.

(*F*) *Permeameter Method.*—This is a method which I have myself devised for the purpose of testing specimens of iron. It is essentially a workshop method, as distinguished from a laboratory method. It requires no ballistic galvanometer, and the iron does not need to be forged into a ring or wound with a coil. For carrying it out a simple instrument is needed, which I venture to denominate as a *permeameter*. Outwardly, it has a general resemblance to Dr. Hopkinson's apparatus, and consists, as you see (Fig. 19), of a rectangular piece of soft wrought-iron, slotted out to receive a magnetizing coil, down the axis of which passes a brass tube. The block is 12 inches long, 6½ inches wide, and 3 inches in thickness. At one end the block is bored to receive the sample of iron that is to be tested. This consists simply of a thin rod about a foot long, one end of which must be carefully surfaced up. When it is placed inside the magnetizing coil, and the exciting current is turned on, the rod sticks tightly at its lower end to the surface of the iron block; and the force required to detach it (or, rather, the square root of that force) is a measure of the permeation of the magnetic lines through its end-face. In the first permeameter which I constructed the magnetizing coil is 13·64 centimetres in length, and has 371 turns of wire. One ampere of exciting current consequently produces a magnetizing force of **H** = 34. The wire is thick enough to carry 30 amperes, so that it is easy to reach a magnetizing force of 1,000. The current I now turn on is 25 amperes. The two rods here are of "charcoal iron" and "best iron" respectively; they are of quarter-inch square stuff. Here is a spring balance graduated carefully, and provided with an automatic catch so that its index stops at the highest reading. The tractive force of the charcoal iron is about 12½ lbs., while that of the "best" iron is only 7½ lbs. **B** is about 19,000 in the charcoal iron, and **H** being 850, μ is about 22·3. The law of traction which I use in calculating **B** will occupy us much in the next lecture, but meantime I content myself in stating it here for use with the permeameter. The formula for calculating **B** when the core is thus detached by a pull of P pounds, the area of contact being A square inches, is as follows:—

$$\mathbf{B} = 1{,}317 \times \sqrt{P \div A} + \mathbf{H}.$$

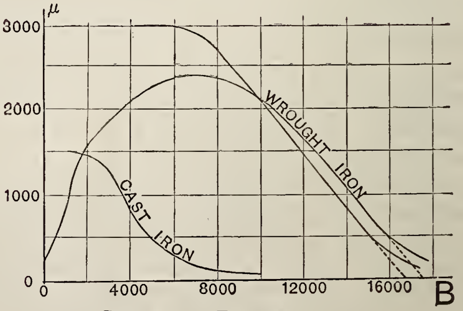
I may add that the instrument, in its final form, is manufactured from my desigus by Messrs. Nalder Bros, the well-known makers of so many electrical instruments,

CURVES OF MAGNETIZATION AND PERMEABILITY.

In reviewing the results obtained, it will be noted that the curves of magnetization all possess the same general features, all tending toward a practical maximum, which, however, is different for different materials. Joule expressed the opinion that "no force of current could give an attraction equal to 200 lbs. per square inch," the greatest he actually attained being only 175 lbs. per square inch. Rowland was of opinion that the limit was about 177 lbs. per square inch for an ordinary good quality of iron, even with infinitely great exciting power. This would correspond roughly to a limiting value of **B** of about 17,500 lines to the square centimetre. This value has, however, been often surpassed. Bidwell obtained 19,820, or possibly a trifle more, as in Bidwell's calculation the value of **H** has been needlessly discounted. Hopkinson gives 18,250 for wrought iron, and 19,840 for mild Whitworth steel. Kapp gives 16,740 for wrought iron, 20,460 for charcoal iron in sheet, and 23,250 for charcoal iron in wire. Bosanquet found the highest value in the middle bit of a long bar to run up in one specimen to 21,428, in another to 29.388, in a third to 27,688. Ewing, working with extraordinary magnetic power, forced up the value of **B** in Lowmoor iron to 31,560 (when μ came down to 3), and subsequently to 45,350. This last figure corresponds to a traction exceeding 1,000 pounds to the square inch.

Cast iron falls far below these figures. Hopkinson, using a magnetizing force of 240, found the values of **B** to be 10,783 in grey cast iron, 12,408 in malleable cast iron, and 10,546 in mottled cast iron. Ewing, with a magnetizing force nearly fifty times as great, forced up the value of **B** in cast iron to 31,760. Mitis metal, which is a sort of cast wrought iron, being a wrought iron rendered fluid by addition of a small per-centage of aluminium, is, as I have found, more magnetizable than cast iron, and not far inferior to wrought iron. It should form an excellent material for the cores of electromagnets for many purposes where a cheap manufacture is wanted.

FIG. 20.



CURVES OF PERMEABILITY.

A very useful alternative mode of studying the results obtained by experiment is to construct curves, such as those of Fig. 20, in which the values of the permeability are plotted out vertically in correspondence with the values of **B** plotted horizontally. It will be noticed that in the case of Hopkinson's specimen of annealed wrought iron, between the points where $\mathbf{B} = 7{,}000$ and $\mathbf{B} = 16{,}000$, the mean values of μ lie almost on a straight line, and might be approximately calculated from the equation :—

$$\mu = (17{,}000 - \mathbf{B}) \div 3 \cdot 5.$$

THE LAW OF THE ELECTROMAGNET.

Many attempts have been made, by Müller, Lamont, Frölich, and others to discover a simple algebraic formula whereby to express the relation between the magnetizing force and the magnetism produced in the electromagnet. According to Müller, these are related to one another in the same proportions as the natural tangent is related to the arc which it subtends. The formulæ of Lamont and Frölich, which are more nearly in keeping with the facts, are based upon the assumption of a relation between the permeability and the degree of magnetization present. Suppose we assume the approximation stated above, that the permeability is proportional to the difference between **B** and some higher limiting value (17,000 for wrought-iron, 7,000 for cast-iron). If this higher value is called β we may write

$$\mu = \frac{\beta - \mathbf{B}}{a},$$

where a is a constant that varies with the quality of the iron or steel.

Now

$$\mathbf{B} = \mu\,\mathbf{H}:$$

giving by substitution and an easy transformation—

$$\mathbf{B} = \beta\,\frac{\mathbf{H}}{a + \mathbf{H}},$$

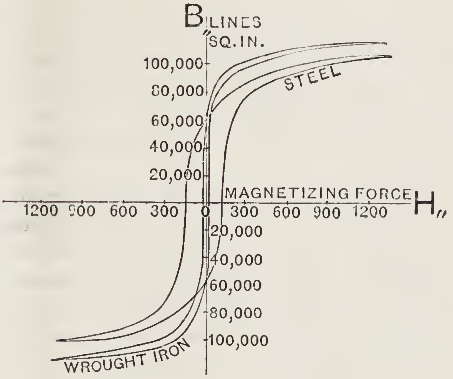
which is one form of Frölich's well-known formula. The constant, a, stands for the "diacritical" value of the magnetizing force, or that value which will bring up **B** to half the assumed limiting or "satural" value.

All such formulæ, however convenient, are insufficient, inasmuch as they fail to take into account the properties of the entire magnetic circuit.

HYSTERESIS.

I have already drawn attention to the difference between the ascending and descending curves of magnetization, and may now point out that this is a part of a set of general phenomena of residual effects. The best known of these effects is, of course, the existence in some kinds of iron, and notably in steel, of a remanent or sub-permanent magnetization after the magnetizing force has been entirely removed. To this retardation of effects behind the causes that produce them the name of "hysteresis" has been given by Prof. Ewing. If a piece of iron is subjected to a magnetizing force which increases to a maximum, then is decreased down to zero, then reversed and carried to a negative maximum, then decreased again to zero, and so carried round an entire cycle of magnetic operations, it is observed that the curves of magnetization form a closed area similar in general to those shown in Fig. 21. This closed area represents the work which has been wasted or dissipated in subjecting the iron to these alternate magnetizing forces. In very soft iron, where the ascending and descending curves are close together, the enclosed area is small; and as a matter of fact, very little energy is dissipated in a cycle of magnetic operations. On the other hand, with hard iron, and particularly with steel, there is a great width between the curves, and there is great waste of energy. Hysteresis may be regarded as a sort of internal or molecular magnetic friction, by reason of which alternate magnetizations cause the iron to grow hot. Hence the importance of understanding this curious effect, in view of the construction of electromagnets that are to be used with rapidly alternating currents. The following figures of Table V. (p. 888) give the number of watts (1 watt $= \frac{1}{746}$ of a horse-power) wasted by hysteresis in well-laminated soft wrought iron when subjected to a succession of rapid cycles of magnetization,

FIG. 21.



CURVES OF HYSTERESIS.

TABLE V.—WASTE OF POWER BY HYSTERESIS.

$\mathbf{B}$	$\mathbf{B}_{''}$	Watts wasted per cubic foot at 10 cycles per second.	Watts wasted per cubic foot at 100 cycles per second.
4,000	25,800	40	400
5,000	32,250	57·5	575
6,000	38,700	75	750
7,000	45,150	92·5	925
8,000	51,600	111	1,110
10,000	64,500	156	1,560
12,000	77,400	206	2,060
14,000	90,300	262	2,620
16,000	103,200	324	3,240
17,000	109,650	394	3,940
18,000	116,100	487	4,870

It will be noted that the waste of energy increases as the magnetization is pushed higher and higher in a disproportionate degree, the waste when $\mathbf{B}$ is 18,000 being six times that when $\mathbf{B}$ is 6,000. In the case of hard iron or of steel the heat waste would be far greater.

Another kind of after-effect was discovered by Ewing, and named by him "viscous hysteresis." This is the name given to the gradual creeping up of the magnetization when a magnetic force is applied with absolute steadiness to a piece of iron. This gradual creeping up may go on for half an hour or more, and amount to several per cent. of the total magnetization.

Another important matter is that all such actions as hammering, rolling, twisting, and the like, impair the magnetic quality of annealed soft iron. Annealed wrought-iron which has never been touched by a tool shows hardly any trace of residual magnetization, even after the application of magnetic forces. But the touch of the file will at once spoil it. Sturgeon pointed out the great importance of this point. In the specification for tenders for instruments for the British Postal Telegraphs, it is laid down as a condition to be observed by the constructor, that the cores must not be filed after being annealed. The continual hammering of the armature of an electromagnet against the poles may in time produce a similar effect.

FALLACIES AND FACTS ABOUT ELECTROMAGNETS.

I will conclude this lecture by stating a few of the fallacies that are current about electromagnets, and will add to them a few facts, some of which seem paradoxical. The refutation of the fallacies and the explanation of the facts will come in due course.

Fallacies.—The attraction of an electromagnet for its armature varies inversely, as the square of its distance from the poles.

The outer windings of an electromagnet are necessarily less effective than those that are close to the iron.

Hollow iron cores are as good as solid cores of the same size.

Pole-pieces add to the lifting power of an electromagnet.

It hurts an electromagnet (or, for that matter a steel magnet) to pull off the keeper suddenly. [It is the sudden slamming on that in reality hurts it.]

The resistance of the coil of an electromagnet ought to be equal to the resistance of the battery.

A coil wound left-handedly magnetizes a magnet differently from a coil wound right-handedly. [It is not a question of winding of coil but of circulation of current.]

Thick-wire electromagnets are less powerful than thin-wire electromagnets.

A badly insulated electromagnet is more powerful than one that is well insulated.

A square iron core is less powerful (as Dal Negro says, eighteen-fold!) than a round core of equal weight.

The attraction of an electromagnet for its keeper is necessarily less strong (one-third according to Du Moncel) sideways than when the keeper is in front of the poles.

Putting a tube of iron outside the coils of an electromagnet makes it attract a distant armature more powerfully.

Facts.—A bar electromagnet with a convex pole holds on tighter to a flat-ended armature than one with a flat pole does.

A thin round disc of iron laid upon the flat round end of an electromagnet (the pole end being slightly larger than the disc) the disc is not attracted, and will not stick on, even if laid down quite centrally.

If a flat armature of iron be presented to the poles of a horse-shoe electromagnet the attraction at a short distance is greater, if the armature is presented flankways, than if it is presented edgeways. On the contrary, the tractive force in contact is greater edgeways than flankways.

Electromagnets with long limbs are practically no better than those with short limbs for sticking on to masses of iron.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

EXAMINATIONS, 1891.

The subjects of examination are—1. Arithmetic; 2. English (including composition and correspondence, and précis writing); 3. Book-keeping; 4. Commercial Geography; 5. Shorthand; 6. Type-writing; 7. French; 8. German; 9. Italian; 10. Spanish; 11. Portuguese; 12. Russian; 13. Danish; 14. Chinese; 15. Japanese; 16. Political Economy; 17. Domestic Economy; 18. Theory of Music; 19. Practice of Music.

These examinations will be held on March 16, 17, 18, and 19, with the exception of that in the Practice of Music, which will be held during the week commencing on the 1st of June.

In addition to the syllabus of examinations, the Programme contains an appendix giving the questions set in 1890, and the reports of the examiners on the papers worked.

The Programme is now ready. Copies can be obtained gratis on application to the Secretary.

Proceedings of the Society.

CANTOR LECTURES.

THE ELECTROMAGNET.

By Professor Silvanus P. Thompson,
D.Sc., B.A., M.I.E.E.

Lecture II.—Delivered January 27th, 1890.

General Principles of Design and Construction. — Principle of the Magnetic Circuit.

To-night we have to discuss the law of the magnetic circuit in its application to the electromagnet, and in particular to dwell upon some experimental results which have been obtained from time to time by different authorities as to the relation between the construction of the various parts of an electromagnet, and the effect of that construction on its performance. We have to deal not only with the size, section, length, and material of the iron cores, and of the armatures of iron, but we have to deal also with the winding of the upper coil, and its form; and we have to speak in particular about the way in which the shaping of the core and of the armature affects the performance of the electromagnet in acting on its armature, whether in contact or at a distance. But before we enter on the last more difficult part of the subject, we will deal solely and exclusively with the law of force of the magnet upon its armature when the two are in contact with one another; in other words, with the law of traction.

I alluded in a historical manner in the last lecture to the principle of the magnetic circuit, telling you how the idea had gradually grown up, perforce, from a consideration of the facts. The law of the magnetic circuit was, however, first thrown into shape in 1873 by Professor Rowland, of Baltimore. He pointed out that if you consider any simple case, and find (as electricians do for the electric circuit) an expression for the magnetizing force which tends to drive the magnetism round the circuit, and divide that by the resistance to magnetization reckoned also all round the circuit, the total of those two gives you the total amount of flow or flux of magnetism. That is to say, one may calculate the quantity of magnetism that passes in that way round the magnetic circuit in exactly the same way as one calculates the strength of the electric current by the law of Ohm. Rowland, indeed, went a great deal further than this, for he applied this very calculation to the experiments made by Joule more than 30 years before, and from those experiments deduced the degree of magnetization to which Joule had driven the iron of his magnets, and by inference obtained the amount of current that he had been causing to circulate. Now this law requires to be written out in a form that can be used for future calculation. To put it in words without any symbols, we must first reckon out from the number of turns of wire in the coil, and the number of amperes of current which circulates in them, the whole *magneto-motive force*—the whole of that which tends to drive magnetism along the piece of iron—for it is, in fact, proportional to the strength of the current, and the number o times it circulates. Next we must ascertain the resistance which the magnetic circuit offers to the passage of the magnetic lines. I here avowedly use Joule's own expression, which was afterwards adopted by Rowland, and, for short, so as to avoid having four words, we may simply call it the *magnetic resistance*. Mr. Heaviside has suggested as an advisable alternative term, magnetic *reluctance*, in order that we may not confuse the resistance to magnetism in the magnetic circuit with the resistance to the flow of current in an electric circuit. However, we need not quarrel about terms; magnetic reluctance is sufficiently expressive. Then having found these two, the quotient of them gives us a number representing—I must not call it the strength of the magnetic current—I will call it simply the quantity or number of magnetic lines which flow round the circuit; or if we could adopt a term which is used on the Continent, we might call it simply *the magnetic flux*: the flux of magnetism being the analogue of the flow of electricity in the electric law. The law of the magnetic circuit may then be stated as follows:—

$$\text{Magnetic flux} = \frac{\text{magneto-motive force}}{\text{reluctance}}.$$

However, it is more convenient to deal with these matters in symbols, and therefore the symbols which I use, and have long been using, ought to be explained to you. For the number of spirals in a winding I use the letter S; for the strength of current, or number of amperes, the letter i; for the length of a bar, or core, I am going to use the letter l; for the area of cross-section, the letter A; for the permeability of the iron which we discussed in the last lecture, the Greek symbol μ; and for the total magnetic flux, the number of magnetic lines, I use the letter N. Then our law becomes as follows:—

$$\text{Magneto-motive force } \frac{4\pi\,Si}{10};$$

$$\text{Magnetic reluctance } \quad \Sigma\frac{l}{A\mu};$$

$$\text{Magnetic flux}\ldots\ldots\ \mathsf{N} = \frac{\dfrac{4\pi\cdot Si}{10}}{\Sigma\dfrac{l}{A\mu}}.$$

If we take the number of spirals and multiply by the number of amperes of current, so as to get the whole amount of circulation of electric current expressed in so many ampere-turns, and multiply by 4π, and divide by ten, in order to get the proper unit (that is to say, multiply it by 1·257), that gives us the magneto-motive force. For magnetic reluctance, calculate out the reluctance exactly as you would the resistance of an electric conductor to the flow of electricity, or the resistance of a conductor of heat to the flow of heat; it will be proportionate to the length, inversely proportional to the cross-section, and inversely proportional to the conductivity, or, in the present case, to the magnetic permeability. Now if the circuit is a simple one, we may simply write down here the length, and divide it by the area of the cross-section and the permeability, and so find the value of the reluctance. But if the circuit be not a simple one, if you have not a simple ring of iron of equal section all round, it is necessary to consider the circuit in pieces as you would an electric circuit, ascertaining separately the reluctance of the separate parts, and adding all together. As there may be a number of such terms to be added together, I have prefixed the expression for the magnetic reluctance by the sign Σ of summation. But it does not by any means follow because we can write a thing down as simply as that, that the calculation out of it will be a very simple matter. In the case of magnetic lines we are quite unable to do as one does with electric currents to insulate the flow. An electric current can be confined (provided we do not put it in at 10,000 volts pressure, or anything much bigger than that) to a copper conductor by an adequate layer of adequately strong—and I use the word "strong" both in a mechanical and electrical sense—of adequately strong insulating material. There are materials whose conductivity for electricity as compared with copper may be regarded perhaps as millions of millions of millions of times less; that is to say, they are practically perfect insulators. There are no such things for magnetism. The most highly insulating substance we know of for magnetism is certainly not 10,000 times less permeable to magnetism than the most highly magnetizable substance we know of, namely, iron in its best condition; and when one deals with electromagnets where curved portions of iron are surrounded with copper, or with air, or other insulating material, one is dealing with substances whose permeability, instead of being infinitely small, compared with the iron is quite considerable. We have to deal mainly with iron when it has been well magnetized. Its permeability compared with air is from 1,000 to 100 roughly; that is to say, the permeability of air compared with the iron is not less than from $\frac{1}{100}$th to $\frac{1}{1000}$th part. That means that it is quite possible to have a very considerable leakage of magnetic lines from iron into air occurring to complicate one's calculations, and prevent an accurate estimate being made of the true magnetic reluctance of any part of the circuit. Suppose, however, that we have got over all these difficulties, and made our calculations of the magnetic reluctance; then dividing the magneto-motive force by the reluctance gives us the whole number of magnetic lines.

There, then, is in its elementary form the law of the magnetic circuit stated exactly as Ohm's law is stated for electric circuits. But as a general rule one requires this magnetic law for certain applications, in which the problem is not to calculate from those two quantities what the total of magnetic lines will be. In most of the cases a rule is wanted for the purpose of calculating back. You want to know how to build a magnet so as to give you the requisite number of magnetic lines. You start by assuming that you need to have so many magnetic lines, and you require to know what magnetic reluctance there will be, and how much magneto-motive force will be needed. Well, that is a matter precisely analogous to those which every electrician comes across. He does not always want to use Ohm's law in the way in which it is commonly stated, to calculate the current from the electromotive force and the resistance; he often wants to calculate what is the electromotive force which will send a given current through a known resistance. And so do we. Our main consideration to-night will be devoted to the question how many ampere-turns of copper wire winding must be provided in order to drive the required quantity of magnetism through any given magnetic reluctance. Therefore, we will state our law a little differently. What we want to calculate out is the number of ampere-turns required. When once we have got that, it is easy to say what the copper wire must consist of; what sort of wire, and how much of it. Turning then to our algebraic rule, we must transform it, so as to get all the other things, beside the ampere-turns, to the other side of the equation. So we write the formula :—

$$S i = \frac{\mathbf{N} \cdot \Sigma \frac{l}{A\,\mu}}{1 \cdot 257}$$

We shall have then the ampere turns equal to the number of magnetic lines we are going to force round the circuit multiplied by the sum of the magnetic reluctances divided by 1·257. Now this number, 1·257, is the constant that comes in when the length, *l*, is expressed in centimetres, the area in square centimetres, and the permeability in the usual numbers. Many persons unfortunately—I say so advisedly because of the waste of brain labour that they have been compelled to go through—prefer to work in inches and pounds and feet. They have, in fact, had to learn tables instead of acquiring them naturally without any learning. If the lengths be specified in inches, and areas in square inches, then the constant is a little different. The constant in that case, for inches and square inch measures, is 0·3133, so that the formula becomes :—

$$S i = \mathbf{N} \times \Sigma \frac{l''}{A''\mu} \times 0 \cdot 3133.$$

Here it is convenient to leave the law of the magnetic circuit, and come back to it from time to time as we require. What I want to point out before I go to any of the applications is, that with the guidance provided by this law, one after another the various points that come under review can be arranged and explained, and that there does not now remain—if one applies this law with judgment—a single fact about electromagnets which is either anomalous or paradoxical. Paradoxical some things may seem in form, but they all reduce to what is perfectly rational when one has a guiding principle of this kind to tell you how much magnetization you will get under given circumstances, or to tell you how much magnetizing power you require in order to get a given quantity of magnetization. I am using the word "magnetization" there in the popular sense, not in the narrow mathematical sense in which it has sometimes been used (*i.e.*, for the magnetic moment per unit cube of the material). I am using it simply to express the fact that the iron or air, or whatever it may be, has been subjected to the process which results in there being magnetic lines of force induced through it.

Now let us apply this law of magnetic circuit in the first place to the traction, that is to say, the lifting power of electromagnets. The law of traction I assumed in my last lecture, for I made it the basis of a method of measuring the amount of permeability. The law of magnetic traction was stated once for all by Maxwell, in his great treatise, and it is as follows :—

$$P \text{ (dynes)} = \frac{\mathbf{B}^2 A}{8\pi},$$

where A is the area in square centimetres. This becomes

$$P \text{ (grammes)} = \frac{\mathbf{B}^2 A}{8\pi \times 981}.$$

That is, the pull in grammes per square centimetre is equal to the square of the magnetic induction, **B** (being the number of magnetic lines to the square centimetre), divided by 8π, and divided also by 981. To bring grammes into pounds you divide by 453·6; so that the formula then becomes:—

$$P \text{ (lbs.)} = \frac{\mathbf{B}^2 A}{11,183,000};$$

or if square inch measures are used:—

$$P \text{ (lbs.)} = \frac{\mathbf{B}_{''}^2 A''}{72,134,000}.$$

To save future trouble we will now calculate out from the law of traction the following Table; in which the traction in grammes per square centimetre or in pounds per square inch is set down opposite the corresponding value of **B**.

TABLE VI.—MAGNETIZATION AND MAGNETIC TRACTION.

B lines per sq. cm.	$\mathbf{B}_{''}$ lines per sq. in.	Dynes per sq. centim.	Grammes per sq. centim.	Kilogrs. per. sq. centim.	Pounds per sq. inch
1,000	6,450	39,790	40·56	·0456	·577
2,000	12,900	159,200	162·3	·1623	2·308
3,000	19,350	358,100	365·1	·3651	5·190
4,000	25,800	636,600	648·9	·6489	9·228
5,000	32,250	994,700	1,014	1·014	14·39
6,000	38,700	1,432,000	1,460	1·460	20·75
7,000	45,150	1,950,000	1,987	1 987	28·26
8,000	51,600	2,547,000	2,596	2·596	36·95
9,000	58,050	3,223,000	3,286	3·286	46·72
10,000	64,500	3,979,000	4,056	4·056	57·68
11,000	70,950	4,815,000	4,907	4·907	69·77
12,000	77,400	5,730,000	5,841	5·841	83·07
13,000	83,850	6,725,000	6 855	6·855	97·47
14,000	90,300	7,800,000	7,550	7·550	113·1
15,000	96,750	8,953,000	9,124	9·124	129·7
16,000	103,200	10,170,000	10,390	10·39	147·7
17,000	109,650	11,500,000	11,720	11 72	166·6
18,000	116,100	12,890,000	13,140	13·14	186·8
19,000	122,550	14,360,000	14,630	14·63	208·1
20,000	129,000	15,920,000	16,230	16·23	230·8

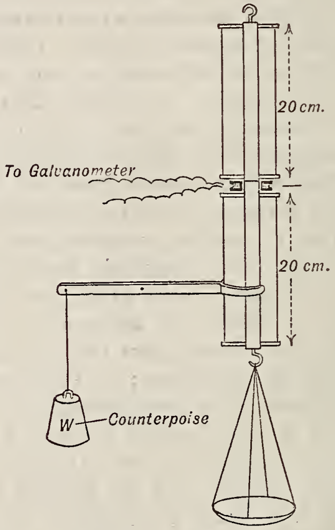
This simple statement of the law of traction assumes that the distribution of the magnetic lines is uniform all over the area we are considering; and that unfortunately is not always the case. When the distribution is not uniform, then the mean value of the squares becomes greater than the square of the mean value, and consequently the pull of the magnet at its end face may, under certain circumstances, become greater than the calculation would lead you to expect—greater than the average of **B** would lead you to suppose. If the distribution is not uniform over the area of contact, then the accurate expression for the tractive force (in dynes) will be

$$P = \frac{1}{8\pi} \int \mathbf{B}^2 dA,$$

the integration being taken over the whole area of contact.

This law of traction has been verified by experiment. The most conclusive investigations were made about 1886 by Mr. R. H. M. Bosanquet, of Oxford, whose apparatus is depicted in Fig. 22. He took two cores of iron, well faced, and surrounded them both by magnetizing coils, fastened the upper one rigidly, and suspended the other one on a lever with a counterpoise weight. To the lower end of this core he hung a scale-pan, and measured the traction of one upon the other when a known current was circulating a known number of times round the coil. At the same time he placed an exploring coil round the joint, that exploring coil being connected, in the manner with which we were experimenting last week, with a ballistic galvanometer, so that at the moment when the two surfaces parted company, or at the moment when the magnetization was released by reversing the magnetizing current, the

FIG. 22.



BOSANQUET'S VERIFICATION OF THE LAW OF TRACTION.

galvanometer indication enabled you to say exactly how many magnetic lines went through that exploring coil. So that, knowing the area, you could calculate the number per square centimetre, and you could therefore compare $\mathbf{B}^2$ with the pull per square centimetre obtained directly on the scale-pan. Bosanquet found that even when the surfaces were not absolutely perfectly faced the correspondence was very close indeed, not varying by more than 1 or 2 per cent. except with small magnetizing forces, say forces less than five units. When one knows how irregular the behaviour of iron is when the magnetizing forces are so small as this, one is not astonished to find a lack of proportionality. The correspondence was, however, sufficiently exact to say that the experiments verified the law of traction, that the pull is proportional to the square of magnetic induction through the area, and integrated over that area.

Now the law of traction being in that way established, one at once begins to get some light upon the subject of the design of electromagnets. Indeed, without going into any mathematics, Joule had foreseen this when he in some instinctive sort of way seemed to consider that the proper way to regard an electromagnet for the purpose of traction was to think how many square inches of contact surface it had. He found that he could magnetize iron up until it pulled with a force of 175 lbs. to the square inch, and he doubted whether a traction as great as 200 lbs. per square inch could be obtained.

In the following Table Joule's results (see Table I., p. 874) are recalculated, and the values of **B** deduced :—

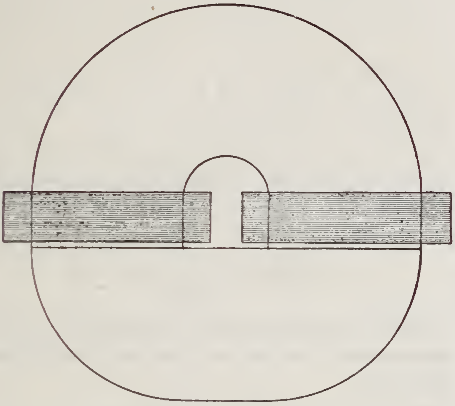
TABLE VII.—JOULE'S RESULTS RE-CALCULATED.

Description of Electromagnet.		Section.		Load.		lbs. per sq. in.	kilos. per sq. cm.	**B**	Ratio of load to weight.
		sq. in.	sq. cen.	lbs.	kilos.				
Joule's own electromagnets	No. 1	10	64·5	209·0	947	104·5	7·35	13,600	139
	No. 2	0·196	1·26	49	22	125	8·75	14,700	324
	No. 3	0·0436	6·28	12	5·4	137·5	9·75	15,410	1,286
	No. 4	0·0012	0·0077	0·202	0·09	81	5·7	11,830	2,384
Nesbit's		4·5	29·1	142·8	647	158·5	11·2	16,550	28
Henry's		3·94	25·3	750	346	95	6·7	12,820	36
Sturgeon's		0·196	1·26	53	22·6	127·5	8·95	14,850	114

I will now return to the data on Table VI., and will ask you to compare the last column with the first. Here are the various values of **B**, that is to say, the amounts of magnetization you get into the iron. You cannot conveniently crowd more than 20,000 magnetic lines to the square centimetre of the best iron, and, as a reference to the curves of magnetization shows, it is not expedient in the practical design of electromagnets to attempt, except in extraordinary cases, to crowd more than about 16,000 magnetic lines into the square centimetre. The simple reason is this, that if you are working up the magnetic force, say from 0 up to 50, a magnetizing force of 50 applied to good wrought iron, will give you only 16,000 lines to the square centimetre, and the permeability by that time has fallen to about 320. If you try to force the magnetization any further, you find that you have to pay for it so greatly. If you want to force another 1,000 lines through the square centimetre, to go from 16,000 to 17,000, you have to add on an enormous magnetizing force; you have to double the whole force from that point to get another 1,000 lines added. Obviously it would be much better to take a larger piece of iron and not to magnetize it too highly—to take a piece a quarter as large again, and to magnetize that less forcibly. It does not therefore pay to go much above 16,000 lines to a square centimetre—that is to say, expressing it in terms of the law of traction, and the lbs. per square inch, it does not pay to design your electromagnet so that it shall have to carry more than about 150 lbs. to the square inch. This shall be our practical rule: let us at once take an example. If you want to design an electromagnet to carry a load of one ton, divide the ton, or 2,240 lbs., by 150, and that gives the requisite number of square inches of wrought iron, namely, 14·92, or say 15. Of course one would work with a horseshoe shaped magnet, or something equivalent —something with a return circuit—and calculate out the requisite cross-section, so that the total area exposed might be sufficient to carry the given load at 150 lbs. to the square inch. And, as a horse-shoe magnet has two poles, the cross-section of the bar of which it is made must be 7½ square inches. If of round iron, it must be about 3½ inches in diameter; if of square iron, it must be 2¾ inch each way.

That settles the size of the iron, but not the length. Now the length of the iron, if one only considers the law of the magnetic circuit, ought to be as short as it can possibly be made. Reflect for what purpose we are designing. The design of an electromagnet is to be considered, as every design ought to be, with a view to the ultimate purpose to be served by that which you are designing. The present purpose is the actual sticking on of the magnet to a heavy weight, not acting on another magnet at a distance, not pulling at an armature separated from it by a thick layer of air; we are dealing with traction in contact. The question is—how long a piece of iron shall we need to bend over? The answer is—take length enough, and no more than enough, to permit of room for winding on the necessary quantity of wire to carry the current which will give the requisite magnetizing power. But this latter we do not yet know; it has to be calculated out by the law of the magnetic circuit. That is to say, we must calculate the magnetic flux, and the magnetic reluctance as best we can; then from these calculate the ampere-turns of current; and from this calculate the needful quantity of copper wire, so arriving finally at the proper length of the iron core. It is obvious the cross-section being given, and the value of **B**, being prescribed, that settles the whole number of magnetic lines, **N**, that will go through the section. It is self-evident that length adds to the magnetic resistance, and, therefore, the longer the length is, the greater have to be the number of ampere-turns of circulation of the current; while the less the length is, the smaller need be the number of ampere-turns of circulation. Therefore you should design the electromagnet as stumpy as possible, that is to say, make it a stumpy arch, even as Joule did when he came across the same problem, and arrived, by a sort of scientific instinct, at the right solution. You should have no greater length of iron than is necessary in order to get the windings on. Then you see we cannot absolutely calculate the length of the iron until we have an idea about the winding, and we must settle, therefore, provisionally, about the windings. Take a simple ideal case. Suppose we had an indefinitely long, straight iron rod, and we wound that from end to end with a magnetizing coil. How thick a coil, how many ampere-turns of circulation per inch length, will you require in order to magnetize up to any particular degree? It is a matter of very simple calculation. You can calculate exactly what the magnetic reluctance of an inch length of the core will be. For example, if you are going to magnetize up to 16,000 lines per square centimetre, the permeability will be 320. You can take the area anything you like, and consider the length of one inch; you can therefore calculate the magnetic reluctance per inch of conductor, and then you can at once say how many ampere-turns per inch would be necessary in order to give the desired indication of 16,000 magnetic lines to the square centimetre. And knowing the properties of copper wire, and how it heats up when there is a current; and knowing also how much heat you can get rid of per square inch of surface, it is a very simple matter to calculate what minimum thickness of copper the fire insurance companies would allow you to use. They would not allow you to have too thin a copper wire, because if you provide an insufficient thickness of copper, you still must drive your amperes through it to get a sufficient number of ampere-turns per inch of length; and if you drive those amperes through copper winding of an insufficient thickness the copper wire will over-heat, and your insurance policy will be revoked. You therefore are compelled, by the practical consideration of not over-heating, to provide a certain thickness of copper wire winding. I have made a rough calculation for certain cases, and I find that for such electromagnets as one may ordinarily deal with, it is not necessary in any case of practical work to use a copper wire winding, the total thickness of which is greater than about half an inch; and, as a matter of fact, if you use as much as half an inch, you need not then wind the coil all along, for if you will use copper wire winding, no matter what the size, whether thin or thick, so that the total thickness of copper outside the iron is half an inch, you can without over heating, using good wrought iron, make one inch of winding do for 20 inches length of iron. That is to say, you do not really want more than $\frac{1}{40}$th of an inch of thickness of copper outside the iron to magnetize up to the prescribed degree of saturation that indefinitely long piece of which we are thinking, without overheating the outside surface in such a way as to violate the insurance rules. Take it roughly, if you wind to a thickness of half an inch, the inch length of copper will magnetize 20 inches length of iron up to the point where **B** equals 16,000. If then we have a bar bent into a sort of horse-shoe in order to make it stick on to a perfectly-fitting armature also of equal section and quality, we really do not want more than one inch along the inner curve for every 20 inches of iron. An extremely stumpy magnet, such as I have sketched in Fig. 23, will therefore do, if one can only get the iron sufficiently homogeneous throughout. If instead of crowding the wire near the polar parts, we could wind entirely all round the curved part, though the layer of copper winding would be half an inch thick inside the arch, it would be much less outside. Such a magnet, provided the armature fitted with perfect accuracy to the polar surfaces, and provided a battery were arranged to send the requisite number of amperes of current through the coils, would pull with a force of one ton, the iron being but 3½ inches in diameter. For my own part, in this case I should prefer not to use round iron, one of square or rectangular section being more convenient; but the round iron would take less copper in winding, as each turn would be of minimum length if the section were circular.

FIG. 23.



STUMPY ELECTROMAGNET.

Now, this sort of calculation requires to be greatly modified directly one begins to deal with any other case. A stumpy short magnetic circuit with great cross-section is clearly the right thing for the greatest traction. You will get the given magnetization and traction with the least amount of magnetizing force when you have the area as great as possible, and the length as small as possible. You will kindly note that I have given you as yet no proofs for the practical rules that I have been using: they must come later. Also I have said nothing about the size of the wire, whether thick or thin. That does not in the least matter; for the ampere-turns of magnetizing power can be made up in any desired way. Suppose we want on any magnet one hundred ampere-turns of magnetizing power, and we choose to employ a thin wire that will only carry half an ampere, then we must wind 200 turns of that thin wire. Or, suppose we choose to wind it with a thick wire that will carry ten amperes, then we shall want only ten turns of that wire. The same weight of copper, heated up by the corresponding current to an equal degree of temperature, will have equal magnetizing power when wound on the same core. But the rules about winding the copper will be considered later.

Now if you look in the text-books that have been written on magnetism for information about the so-called lifting power or portative force of magnets you will find that from the time of Bernoulli downwards, the law of portative force has claimed the attention of experimenters, who, one after another have tried to give the law of portative force in terms of the weight of the magnets; usually dealing with permanent magnets, not electromagnets. Bernoulli gave a rule something of the following kind, which is commonly known as Häcker's rule—

$$P = a \sqrt[\frac{3}{2}]{W};$$

where W is the weight of the magnet, P, the greatest load it will sustain, and *a* a constant depending on the units of weight chosen, on the quality of the steel, and on its goodness of magnetization. If the weights are in pounds then *a* is found, for the best steels, to vary from 18 to 24 in magnets of horseshoe shape. This expression is equivalent to saying that the power which a magnet can exert—he was dealing with steel magnets; there were no electromagnets in Bernoulli's time—is equal to some constant multiplied by the three-halfth root of the weight of the magnet itself. The rule is accurate only if you are dealing with a number of magnets all of the same geometrical form, all horseshoes let us say, of the same general shape, made from the same sort of steel, similarly magnetised. In former years I pondered much on Häcker's rule, wondering how on earth the three-halfth root of the weight could have anything to do with the magnetic pull; and having cudgelled my brains for a considerable time, I saw that there was really a very simple meaning in it. What I arrived at was this. If you are dealing with a given material, say hard steel, the weight is proportional to the volume, and the cube root of the volume is something proportional to the length, and the square of the cube root forms something proportional to the square of the length, that is to say, to something of the nature of a surface. What surface? Of course the polar surface. This complex rule, when thus analysed, turns out to be merely a mathematician's expression of the fact that the pull for a given material magnetized in a given way is proportional to the area of the polar surface; a law which in its simple form Joule seems to have arrived at naturally, and which in this extraordinarily academic form was arrived at by comparing the weights of magnets with the weight which they would lift. You will find it stated in many books that a good magnet will lift 20 times its own weight. There never was a more fallacious rule written. It is perfectly true that a good steel horse-shoe magnet weighing 1 lb. ought to be able to pull with a pull of 20 lbs. on a properly-shaped armature. But it does not follow that a magnet which weighs 2 lbs. will be able to pull with a force of 40 lbs. It ought not to, because a magnet that weighs 2 lbs. has not poles twice as big if it is the same shape. In order to have poles twice as big you must remember that three-halfth root coming in. If you take a magnet that weighs eight times as much, it will have twice the linear dimensions and four times the surface; and with four times the surface in a magnet of the same form, similarly magnetized, you will have four times the pull. With a magnet eight times as big you will have only four times the pull. The pull, when other things are equal, goes by surface, and not by weight, and therefore it is ridiculous to give a rule saying how many times its own weight a magnet will pull. It is also narrated as a very extraordinary thing that Sir Isaac Newton had a magnet, a loadstone, which he wore in a signet ring, which would lift 234 times its own weight. I have had an electromagnet which would lift 2,500 times its own weight, but then it was a very small one, and did not weigh more than a grain and a-half. When you come to small things, of course the surface is large proportionally to the weight; the smaller you go, the larger becomes that disproportion. This all shows that the old law of traction in that form was practically valueless, and did not guide you to anything at all, whereas the law of traction as stated by Maxwell, and explained further by the law of the magnetic circuit, proves a most useful rule.

From this digression let us return to the law of the magnetic circuit. I gave you in my first lecture, when speaking of permeability, the following rule for calculating the magnetic permeability. **B** was found in the following way:—Take the pull in lbs., and the area of cross-section in square inches, divide one by the other, and take the square root of the quotient; then multiplying by 1317 gives **B**; or multiplied by 8494 gives $\mathbf{B}_{\prime\prime}$. We have therefore a means of stepping from the pull per sq. inch to $\mathbf{B}_{\prime\prime}$, or from $\mathbf{B}_{\prime\prime}$ to the pull per sq. inch. Now the other rule of the magnetic circuit also enables us to get from the ampere-turns down to $\mathbf{B}_{\prime\prime}$, for on p. 891, we have the following expression for the ampere-turns:—

$$S i = \mathbf{N} \times \Sigma \frac{l''}{A''\mu} \times 0{\cdot}3133,$$

and **N**, the whole number of magnetic lines in the magnetic circuit is equal to $\mathbf{B}_{\prime\prime}$ multiplied by A'', or

$$\mathbf{N} = \mathbf{B}_{\prime\prime} A''.$$

From these we can deduce a simple direct expression, provided we assume the quality of iron as before, and also assume that there is no magnetic leakage, and that the area of cross-section is the same all round the circuit, in the armature as well as in the magnet core. So that l'' is simply the mean total path of the magnetic lines all round the closed magnetic circuit. We may then write

$$S i = \frac{\mathbf{B}_{\prime\prime}\, l''}{\mu} \times 0{\cdot}3133;$$

whence

$$\mathbf{B}_{\prime\prime} = \frac{\mu \times S i}{l'' \times 0{\cdot}3133}.$$

But by the law of traction, as stated above,

$$\mathbf{B}_{\prime\prime} = 8494 \sqrt{\frac{P \text{ (lbs.)}}{A \text{ (sq. in.)}}}$$

Equating together these two values of $\mathbf{B}_{\prime\prime}$, and solving, we get for the requisite number of ampere-turns of circulation of exciting currents:—

$$S i = 2661 \times \frac{l''}{\mu} \times \sqrt{\frac{P \text{ (lbs.)}}{A \text{ (sq. in.)}}}$$

This, put into words, amounts to the following rule for calculating the amount of exciting power that is required for an electromagnet pulling at its armature, in the case where there is a closed magnetic circuit with no leakage of magnetic lines. Take the square root of the pounds-per-square-inch; multiply this by the mean total length (in inches) all round the iron circuit; divide by the permeability (which must be calculated from the pounds-per-square-inch by help of Table VI. and Table II.); and finally multiply by 2,661: the number so obtained will be the number of ampere-turns. One goes then at once from the pull per square inch to the number of ampere-turns required to produce that pull in a magnet of given length, and of the prescribed quality. In the case where the pull is specified in kilogrammes, the area of section in square centimetres, and the length in centimetres, the formula becomes

$$Si = 3951 \cdot \frac{l}{\mu} \sqrt{\frac{P}{A}}.$$

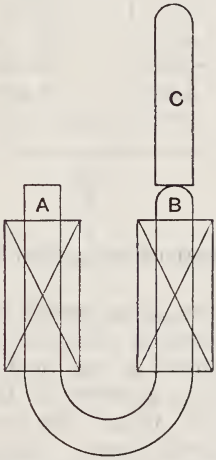
As an example, take a magnet core of round annealed wrought iron, half an inch in diameter, 8 inches long, bent to horse-shoe shape. As an armature, another piece, 4 inches long, bent to meet the former. Let us agree to magnetize the iron up to the pitch of pulling with 112 lbs. to the square inch. Reference to Table VI. shows that $\mathbf{B}_{\prime\prime}$ will be about 90,000, and Table II. shows that in that case μ will be about 907. From these data calculate what load the magnet will carry, and how many ampere-turns of circulation of current will be needed.

Ans.—Load (on two poles) = 43·97 lbs.
Ampere-turns needed = 372·5

N.B.—In this calculation it is assumed that the contact surface between armature and magnet is perfect. It never is; the joint offers additional resistance to the magnetic lines, and there will be some leakage. It will be shown later how to estimate these effects, and to allow for them in the calculations.

Here let me go to a matter which has been one of the paradoxes of the past. In spite of Joule, and of the laws of traction, showing that the pull is proportional to the area, you have this anomaly—that if you take a bar-magnet having flat ended poles, and measure the pull which its pole can exert on a perfectly flat armature, and then deliberately spoil the truth of the contact surface, rounding it off, so making the surface gently convex, the convex pole, which only touches at a portion of its area instead of over the whole, will be found to exert a bigger pull than the perfectly flat one. It has been shown by various experimenters, particularly by Nicklès, that if you want to increase the pull of a magnet with armatures, you may reduce the polar surface. Old steel magnets were frequently purposely made with a rounded contact surface. There are plenty of examples. Suppose you take a straight round core, or one leg of a horseshoe would do equally well, and take a flat-ended rod of iron of same diameter as an armature; stick it on endwise, and measure the pull when a given amount of ampere-turns of current is circulating round. Then having measured the pull, remove it and file it a little, so as to reduce it at the edges, or actually take a slightly smaller piece of iron, or a narrower piece, so that it will actually be exerting its power over a smaller area, you will get a greater pull. What is the explanation of this extraordinary fact? A fact it is, and I will show it to you. Here, Fig. 24, is a small electromagnet which we can place with its poles upwards. This was very carefully made, the iron poles very nicely faced, and on coming to try them it was found they were nearly equal, but one pole, A, was a little stronger than the other. We have, therefore, rounded the other pole, B, a little, and here I will take a piece of iron, C, which has itself been slightly rounded at one end, though it is flat at the other. I now turn on the current to the electromagnet, and I take a spring-balance, so that we can measure the pull at either of the two poles. When I put the flat end of C to the flat pole A, so that there is an excellent contact, I find the pull about 2½ lbs. Now try the round end of C on the flat pole, A; the pull is about 3 lbs. The flat end of C on the round pole B is also about 3 lbs. But if now I put

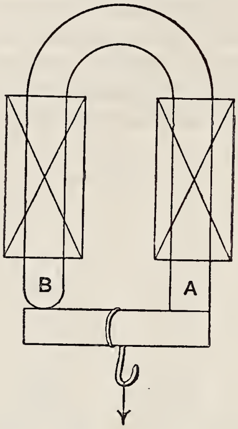
FIG. 24.



EXPERIMENT ON ROUNDING ENDS.

together two surfaces that are both rounded, I get almost exactly the same pull as at first with the two flat surfaces. I have made many experiments on this, and so have others. Take the following case:—There is hung up a horse-shoe magnet, one pole being slightly convex and the other absolutely flattened, and there is put at the bottom, on a square bar armature, over which is slipped a hook to which weights can be hung. Which end of the armature do you think will be detached first?

Fig. 25.



Experiment of Detaching Armature.

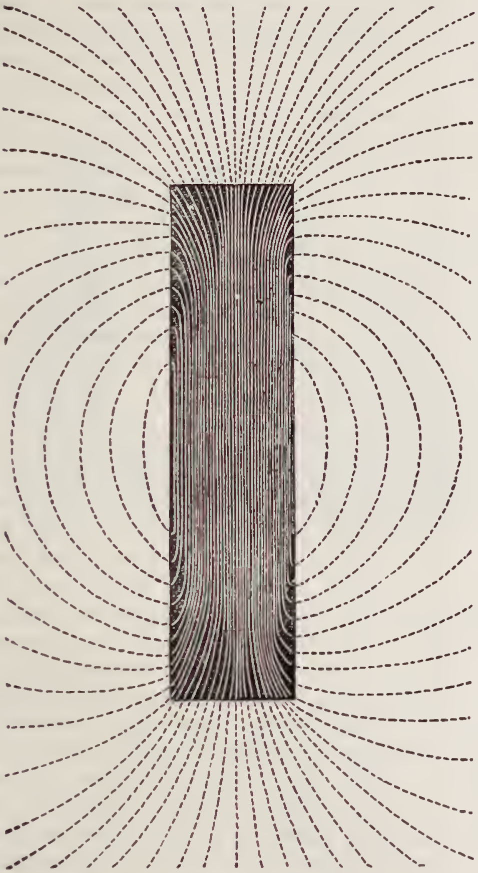
If you were going simply by the square inches, you would say this square end will stick on tighter; it has more gripping surface. But, as a matter of fact, the other sticks tighter. Why? We are dealing here with a magnetic circuit. There is a certain total magnetic reluctance all round it, and the whole number of magnetic lines generated in the circuit depends on two things—on the magnetizing force, and on the reluctance all round; and, saving a little leakage, it is the same number of magnetic lines which come through at B as go through at A. But here, owing to the fact that there is at B a better contact at the middle than at the edges of the pole, the lines are crowded into a smaller space, and therefore at that particular place $\mathbf{B}_{''}$, the number of lines per square inch runs up higher, and when you square the larger number, its square becomes still larger in proportion. In comparing the square of smaller $\mathbf{B}_{''}$ with the square of greater $\mathbf{B}_{''}$, the square of the smaller $\mathbf{B}_{''}$ over the larger area turns out to be less than the square of the larger $\mathbf{B}_{''}$ integrated over the smaller area. It is the law of the square coming in.

As an example, take the case of a magnet pole formed on the end of a piece of round iron 1·15 inch in diameter. The flat pole will have 1·05 inches area. Suppose the magnetizing forces are such as to make $\mathbf{B}_{''} = 903000$, then, by Table VI., the whole pull will be 118·75 lbs., and the actual number of lines through the contact surface will be $\mathbf{N} = 94815$. Now suppose the pole be reduced by rounding off the edge till the effective contact area is reduced to 0·9 sq. inches. If all these lines were crowded through that area, that would give a rate of 105630 per square inch. Suppose, however, that the additional reluctance and the leakage reduced the number by 2 per cent., there would still be 103500 per square inch. Reference to Table VI. shows that this gives a pull of 147·7 lbs. per sq. inch, which multiplied by the reduced area 0·9 gives a total pull of 132·9 lbs., which is larger than the original pull.

Let me show you yet another experiment. This is the same electromagnet (Fig. 24) which has one flat pole and one rounded pole. Here is an armature, also bent, having one flat and one rounded pole. If I put flat to flat, and round to round, and pull at the middle, the flat to flat detaches first; but if we take round to flat, and flat to round, we shall probably find they are about equally good—it is hard to say which holds the stronger.

The law of traction can again be applied to test the so-called distribution of free magnetism on the surface. This is a subject on which I shall have to say a good deal. We must therefore carefully consider what is meant by the phrase. Let Fig. 26 (p. 899) be a rough drawing of an ordinary bar magnet. Every one knows that if we dip such a magnet into iron filings the small bits of iron stick on more especially at the ends, but not exclusively, and if you hold it under a piece of paper or cardboard, and sprinkle iron filings on the paper, you obtain curves like those shown on the diagram. They attest the distribution of the magnetic forces in the external space. The magnetism running internally through the body of the iron begins to leak out sideways, and finally all the rest leaks out in a great tuft at the end. These magnetic lines pass round to the other end, and there go in again, and the place where the steel is internally most highly magnetized is this place across the middle, where externally no iron filings at all stick to it. Now, we have to think of magnetism from the inside and not the outside. This magnetism extends in lines, coming up to the surface somewhere near the ends of the bar, and the filings stick on wherever the magnetism comes up to the surface. They do not stick on at the middle part of the bar, where the metal is really most completely permeated through and through by the magnetism; there are a larger number of lines per square centimetre of cross-section in the middle region where none come up to the surface, and no filings stick on. Now, we may explore the leakage of magnetic lines at various points of the surface of the magnet by the method of traction. We can thereby arrive at a kind of measure of the amount of magnetism that is leaking, or, if you like to call it so, of the intensity of the "free magnetism" at the surface. I do not like to have to use these ancient terms, because they suggest the ancient notion that magnetism was a fluid or, rather, two fluids, one of which was plastered on at one end of the magnet, and the other at the other, just as you might put red paint or blue paint over the ends. I only use that term because it is already more or less familiar. Here is one of the ways of experimentally exploring the so-called distribution of free magnetism. The method was, I believe, originally due to Plücker; at any rate, it was much used by him. This little piece of apparatus was arranged by my friend and predecessor, Professor Ayrton, for the purpose of teaching his students at the Finsbury College. Here is a bar magnet of steel, marked in centimetres from end to end; over the top of it there is a little steel-yard, consisting of a weight sliding along an arm. At the end of that steel-yard there is suspended a small bullet of iron. If we bring that bullet into contact with the bar magnet anywhere near the end, and equilibrate the pull by sliding the counterpoise along the steel-yard arm, we shall obtain the definite pull required to detach that piece of iron. The pull will be proportional, by Maxwell's rule, to the square of the number of magnetic lines coming up from the bar into it. Shift the magnet on a whole centimetre, and attach the bullet a little further on; now equilibrate it, and we shall find it will require a rather smaller force to detach it. Try it again, at points along from the end to the middle. The greatest force required to detach it will be found at the extreme corner, and a little less a little way on, and so on until we find at the middle the bullet does not stick on at all, simply because there are here no magnetic lines leaking. The method is not perfect, because it obviously depends on the magnetic properties of the little bullet, and whether much or little saturated with magnetism. Moreover, the presence of the bullet perturbs the very thing that is to be measured. Leakage into air is one thing; leakage into air perturbed by the presence of the little bullet of iron, which invites leakage into itself, is another thing. It is an imperfect experiment at the best, but a very instructive one. This method has been used again and again in various cases for exploring the apparent magnetism on the surface. I shall use it hereafter, reserving the right to interpret the result by the light of the law of traction.

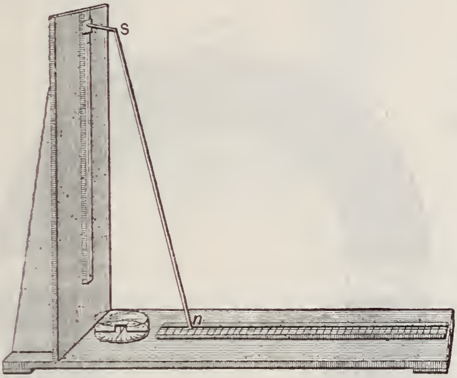
Fig. 26.



Lines of Force running through Bar Magnet.

I now pass to the consideration of the attraction of a magnet on a piece of iron at a distance. And here I come to a very delicate and complicated question. What is the law of force of a magnet—or electromagnet—acting at a point some distance away from it? I have a very great controversy to wage against the common way of regarding this. The usual thing that is proper to say is that it all depends on the law of inverse squares. Now, the law of inverse squares is one of those detestable things needing to be abolished, which, although it may be true in abstract mathematics, is absolutely inapplicable with respect to electromagnets. The only use, in fact, of the law of inverse squares, with respect to electromagnetism, is to enable you to write an answer when you want to pass an academical examination, set by some fossil examiner, who learned it years ago at the University, and never tried an experiment in his life to see if it was applicable to an electromagnet. In academical examinations they always expect you to give the law of inverse squares. What is the law of inverse squares? We had better understand what it is before we condemn it. It is a statement to the following effect—that the action of the magnet (or of the pole some people say), at a point at a distance away from it, varies inversely as the square of the distance from the pole. There is a certain action at one inch away. Double the distance; the square of that will be four, and, inversely, the action will be $\frac{1}{4}$; at double the distance the action is $\frac{1}{4}$; at three times the distance the action is $\frac{1}{9}$, and so on. You just try it with any electromagnet; nay, take any magnet you like, and unless you hit upon the particular case, I believe you will find it to be universally untrue. Experiment does not prove it. Coulomb, who was supposed to establish the law of inverse squares by means of the torsion balance, was working with long thin needles of specially hard steel, carefully magnetised so that the only leakage of magnetism from the magnet might be as nearly as possible leakage in radiating tufts at the very ends. He practically had point-poles. When the only surface magnetism is at the end faces, the magnetic lines leak out like rays from a centre, in radial lines. Now the law of inverse squares is never true except for the action of points; it is a "point" law. If you could get an electromagnet or a magnet, with poles so small in proportion to its length that you can consider the end face of it as the only place through which magnetic lines leak up into the air, and the ends themselves so small as to be relatively mere points; if, also, you can regard those end faces as something so far away from whatever they are going to act upon that the distance between them shall be large compared with their size, and the end itself so small as to be a point, then, and then only, is the law of inverse squares true. It is a law of the action of points. What do we find with electromagnets? We are dealing with pieces of iron which are not infinitely long with respect to their cross-section, and generally possessing round or square end-faces of definite magnitude, which are quite close to the armature; and which are not so infinitely far away that you can consider the polar face a point as compared with its distance away from the object upon which it is to act. Moreover, with real electromagnets there is always lateral leakage; the magnetic lines do not all emerge from the iron through the end face. Therefore, the law of inverse squares is not applicable to that case. What do we mean by a pole, in the first place? We must settle that before we can even begin to apply any law of inverse squares. When leakage occurs all over a great region, as shown in this diagram, every portion of the region is polar; the word polar simply means that you have a place somewhere on the surface of the magnet where filings will stick on; and if filings will stick on to a considerable way down toward the middle all that region must be considered polar, though more strongly at some parts than at others. There are some cases where you can say that the polar distribution is such that the magnetism leaking through the surface acts as if there were a magnetic centre of gravity a little way down, not actually at the end; but cases where you can say there is such a distribution as to have a magnetic centre of gravity are strictly few. When Gauss had to make up his magnetic measurements of the earth, to describe the earth's magnetism, he found it absolutely impossible to assign any definite centre of gravity to the observed distribution of magnetism over the northern regions of the earth; that, indeed, there was not in this sense any definite magnetic pole to the earth at all. Nor is there to our magnets. There is a polar region, but not a pole; and if there is no centre of gravity of the surface magnetism that you can call a pole from which to measure distance, how about the law of inverse squares? Allow me to show you an apparatus (Fig. 27, p. 901), the only one I ever heard of in which the law of inverse squares is true. Here is a very long thin magnet of steel, about 3 feet long, very carefully magnetized so as to have no leakage until quite close up to the end. The consequence is that for practical purposes you may treat this as a magnet having point poles, about an inch away from the ends. The south pole is upwards, and the north pole is below, resting in a groove in a base-board which is graduated with a scale, and is set in a direction east and west. I use a long magnet, and keep the south pole well away, so that it shall not perturb the action of the north pole, which, being small, I ask to be allowed to consider as a point. I am going to consider this point as acting on a small compass needle suspended over a card under this glass case constituting a little magnetometer. If this were properly arranged in a room free from all other magnets, and set so that that needle shall point north, what will be the effect of having the north pole of the long magnet at some distance eastwards? It will repel the north end and attract the south, producing a certain deflexion which we can read off; reckoning the force which causes it by calculating the tangent of the angle of the deflexion. Now, let us move the north pole (regarded as a point) nearer or farther, and study the effect. Suppose we halve the distance from the pole to the indicating needle, the deflecting force at half the distance is four times as great; the force at double the distance is one quarter as great. Wherefore? Because, firstly, we have taken a case where the distance apart is very great, compared with the size of the pole; secondly, the pole is practically concentrated at a point; thirdly, there is only one pole acting; and, fourthly, this magnet is of hard steel, and its magnetism in no way depends on the thing it is acting on, but is constant. I have carefully made such arrangements that the other pole shall be in the axis of rotation, so that its action on the needle shall have no horizontal component. The apparatus is so arranged that whatever the position of that north pole, the south pole, which merely slides perpendicularly up and down on a guide, is vertically over the needle, and therefore does does not tend to turn it round in any direction whatever. With this apparatus one can approximately verify the law of inverse squares. But this is not like any electromagnet ever used for any useful purpose. You do not make electromagnets long and thin, with point poles a very large distance away from the place where they are to act; no, you use them with large surfaces close up to their armature.

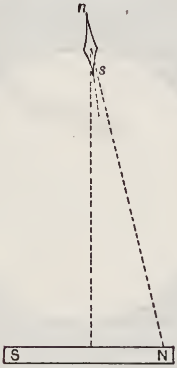
FIG. 27.



APPARATUS TO ILLUSTRATE THE LAW OF INVERSE SQUARES.

There is yet another case which follows a law that is not a law of inverse squares. Suppose you take a bar magnet, not too long, and approach it broadside-on towards a small compass needle, Fig. 28. Of course, you know as soon as you get anywhere near the compass needle it turns round. Did you ever try whether the effect is inversely proportional to the square of the distance reckoned from the middle of the compass needle to the middle of the magnet? Do you think that the deflexions will vary inversely with the squares of the distances? You will find they do not. When you place the bar-magnet like that, broadside-on to the needle, the deflexions vary as the cube of the distance, not the square.

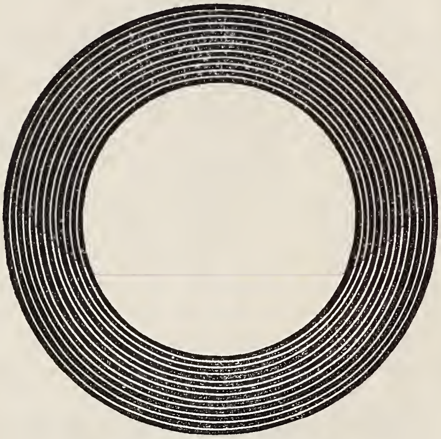
FIG. 28.



DEFLEXION OF NEEDLE CAUSED BY BAR MAGNET BROADSIDE-ON.

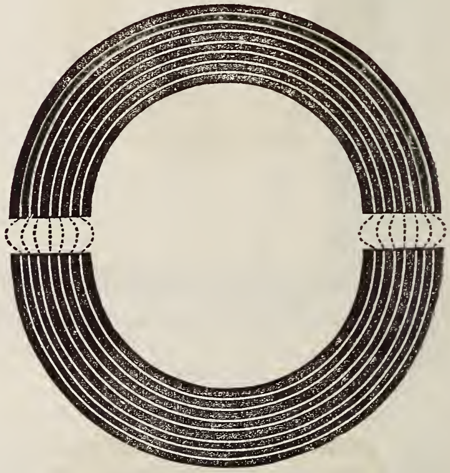
Now, in the case of an electromagnet pulling at its armature at a distance, it is utterly impossible to state the law in that misleading way. The pull of the electromagnet on its armature is not proportional to the distance, nor to the square of the distance, nor to the cube, nor to the fourth power, nor to the square root, nor to the three-halfth root, nor to any other power of the distance whatever, direct or inverse, because you find, as a matter of fact, that as the distance alters something else alters too. If your poles were always of the same strength, if they did not act on one another, if they were not affected by the distance in between, then some such law might be stated. If we could always say, as we used to say in the old language, "at that pole," or "at that point," there are to be considered so many "units of magnetism," and at that other place so many units, and those are going to act on one another; then you could, if you wished, calculate the force by the law of inverse squares. But that does not correspond to anything in fact, because the poles are not points, and further, the quantity of magnetism on them is not a fixed quantity. As soon as the iron armature is brought near the pole of the electromagnet there is a mutual interaction; more magnetic lines flow out from the pole than before, because it is easier for magnetic lines to flow through iron than through air. Let us consider a little more narrowly that which happens when a layer of air is introduced into the magnetic circuit of an electromagnet. Here we have (Fig. 29) a closed magnetic circuit, a ring of iron, uncut, such as that on which we experimented last week. The only reluctance in the path of the magnetic lines is that of the iron, and this reluctance we know to be small. Compare Fig. 29 with Fig. 30, which represents a divided ring with air gaps in between the severed ends. Now air is a less permeable medium for magnetic lines than iron is, or, in other words, it offers a greater magnetic reluctance. The magnetic permeability of iron varies as we know both with its quality and with the degree of magnetic saturation. Reference to Table III. shows that if the iron has been magnetized up so as to carry 16,000 magnetic lines per square centimetre, the permeability at that stage is about 320. Iron at that stage conducts magnetic lines 320 times better than air does; or air offers 320 times as much reluctance to magnetic lines as iron (at that stage) does. So then the reluctance in the gaps to magnetization is 320 times as great as it would have been if the gaps had been filled up with iron. Therefore, if you have the same magnetizing coil with the same battery at work, the introduction of air-gaps into the magnetic circuit will, as a first effect, have the result of decreasing the number of magnetic lines that flow round the circuit. But this first effect itself produces a second effect. There are fewer magnetic lines going through the iron. Consequently if there were 16,000 lines per square centimetre before there will now be fewer—say only 12,000 or so. Now refer back to Table III., and you will find that when **B** is 12,000 the permeability of the iron is not 320 but 1,400 or so. That is to say at this stage, when the magnetization of the iron has been pushed only so far, the magnetic reluctance of air is 1,400 times greater than that of iron, so that there is a still further throttling of the magnetic circuit by the reluctance so offered by the air-gaps.

FIG. 29.



CLOSED MAGNETIC CIRCUIT.

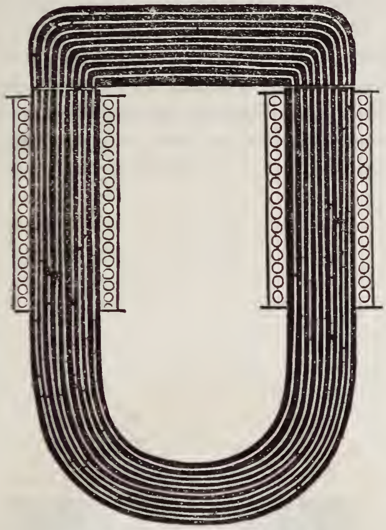
FIG. 30.



DIVIDED MAGNETIC CIRCUIT.

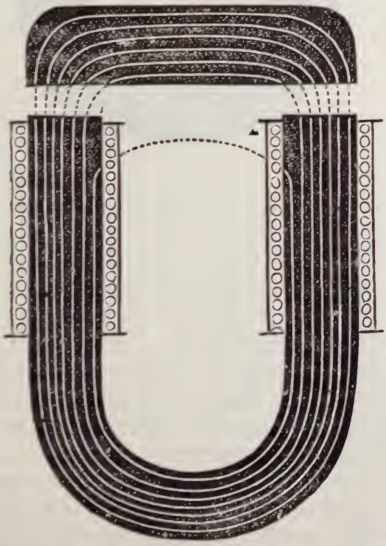
Apply that to the case of an actual electromagnet. Here is a diagram, Fig. 31, representing a horse-shoe electromagnet with an armature of equal section in contact with it. The actual electromagnet for the experiment is here on the table. You can calculate out from the section, the length of iron, and the table of permeability, how many ampere-turns of excitation will produce any required pull. But now consider that same electromagnet, as in Fig. 32, with a small air-gap between the armature and the polar faces. The same circulation of current will not now give you as much magnetism as before, because you have interposed air gaps; and by the very fact of putting in reluctance there, the number of magnetic lines is reduced.

FIG. 31.



ELECTROMAGNET WITH ARMATURE IN CONTACT.

FIG. 32.



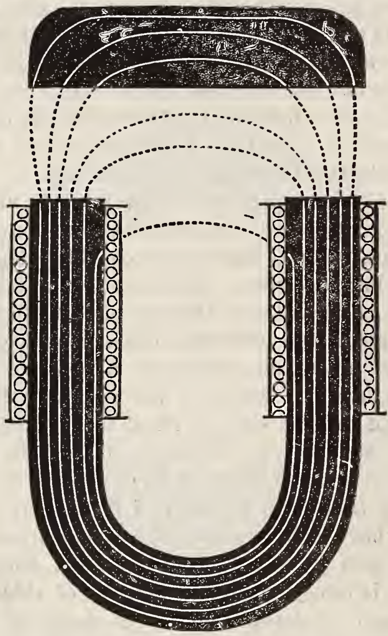
ELECTROMAGNET WITH AIR-GAPS ONE MILLIMETRE WIDE.

Try, if you like, to interpret this in the old way by the old notion of poles. The electromagnet has two poles, and these excite induced poles in the opposite surface of the armature, resulting in attraction. If you double the distance from the pole to the iron, the magnetic force (always supposing the poles are mere points) will be one quarter, hence the induced pole on the armature will only be one quarter as strong. But the pole of the electromagnet is itself weaker. How much weaker? The law of inverse squares does not give you the slightest clue to this all-important fact. If you cannot say how much weaker the primary pole is, neither can you say how much weaker the induced pole will be, for the latter depends upon the former. The law of inverse squares in a case like this is absolutely misleading.

Moreover, a third effect comes in. Not only do you cut down the magnetism by making an air-gap, but you have a new consideration to take into account. Because the magnetic lines, as they pass up through one of the air-gaps along the armature, down the air-gap, at the other end, encounter a considerable reluctance, the whole of the magnetic lines will not go that way; a lot of them will take some shorter cut, although it may be all through air, and you will have some leakage across from limb to limb. I do not say you never have leakage under other circumstances; even with an armature in apparent contact there is always a certain amount of sideway leakage. It depends on the goodness of the contact. And if you widen the air-gaps still further, you will have still more reluctance in the path, and still less magnetism, and still more leakage. Fig. 33 (p. 904) roughly indicates this further stage. The armature will be far less strongly pulled, because, in the first place, the increased reluctance strangles the flow of magnetic lines, so that there are fewer of them in the magnetic circuit; and, in the second place, of this lesser number only a fraction reach the armature because of the increased leakage. When you take the armature entirely away the only magnetic lines that go through the iron are those that flow by leakage across the air from the one limb to the other. This is roughly illustrated by Fig. 34 (p. 904), the last of this set.

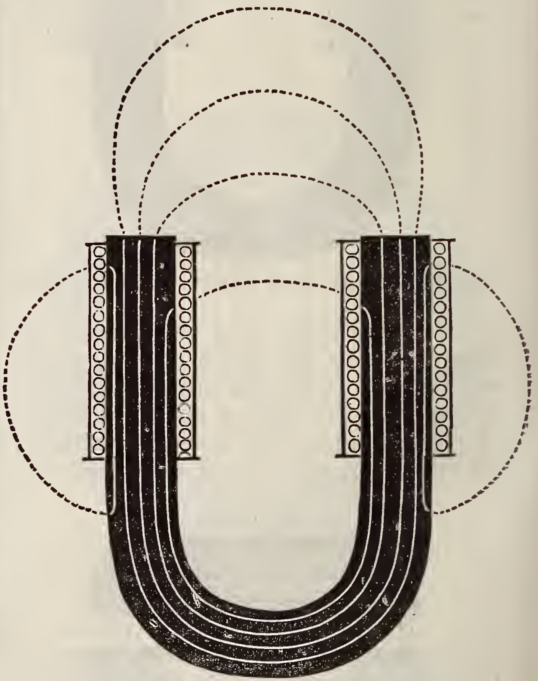
Leakage across from limb to limb is always a waste of the magnetic lines, so far as useful purposes are concerned. Therefore it is clear that, in order to study the effect of introducing the distance between the armature and the magnet, we have to take into account the leakage; and to calculate the leakage, is no easy matter. There are so many considerations that occur as to that which one has to take into account, that it is not easy to choose the right ones and leave the wrong ones. Calculations we must make by-and-bye —they will be added as an appendix to this lecture—but for the moment experiment seems to be the best guide.

FIG. 33.



I will therefore refer, by way of illustrating this question of leakage, to some experiments made by Sturgeon. Sturgeon had a long tubular electromagnet made of a piece of old musket barrel of iron wound with a coil; he put a compass needle about a foot away, and observed the effect. He found the compass needle deflected about 23°; then he got a rod of iron of equal length and put it in at the end, and found that putting it in so that only the end was introduced—in the manner I am now illustrating to you on the table—the deflection increased from 23° to 37°; but when he pushed the iron right home into the gun barrel it went back to nearly 23°. How do you account for that? He had unconsciously increased its facility for leakage when he lengthened out the iron core. And when he pushed the rod right home into the barrel, the extra leakage which was due to the added surface could not and did not occur. There was additional cross-section, but what of that? The additional cross-section is practically of no account. You want to force the magnetism across some 20 inches of air which resists from 300 to 1,000 times as much as iron. What is the use of doubling the section of the iron? You want to reduce the air reluctance, and you have not reduced the air by putting a core into the tube.

FIG. 34.



There is a paradoxical experiment which we will try next week, that illustrates an important principle. If you take a tubular electromagnet and put little pieces of iron into the ends of the iron tube that serves as core, and then magnetize it, the little pieces of iron will try to push themselves out. There is always a tendency to try and increase the completeness of the magnetic circuit; the circuit tends to re-arrange itself so as to make it easier for the magnetic lines to go round.

Here is another paradoxical experiment. I have here a bar electromagnet, which we will connect to the wires that bring the exciting current. In front of it, and at a distance from one end of the iron core, is a small compass needle with a feather attached to it as a visible indicator, so that when we turn on the current the electromagnet will act on the needle, and you will see the feather turn round. It is acting there at a certain distance. The magnetizing force is mainly spent not to drive magnetism round a circuit of iron, but to force it through the air, flowing from one end of the iron core out into the air, passing by the compass needle, and streaming round again, invisible, into the other end of the iron core. It ought to increase the flow if we can in any way aid the magnetic lines to flow through the air. How can I aid this flow? By putting on something at the other end to help the magnetic lines to get back home. Here is a flat piece of iron. Putting it on here at the hinder end of the core ought to help the flow of magnetic lines. You see that the feather makes a rather larger excursion. Taking away the piece of iron diminishes the effect. So also in experiments on tractive power, it can be proved that the adding of a mass of iron at the far end of a straight electromagnet greatly increases the pulling power at the end that you are working with; while, on the other hand, putting the same piece of iron on the front end as a pole-piece greatly diminishes the pull. Here, clamped to the table, is a bar electromagnet excited by the current; and here is a small piece of iron attached to a spring balance, by means of which I can measure the pull required to detach it. With the current which I am employing, the pull is about 2½ lbs. I now place upon the front end of the core this block of wrought iron; it is itself strongly held on; but the pull which it itself exerts on the small piece of iron is small. Less than half a pound suffices to detach it. I now remove the iron block from the front end of the core, and place it upon the hinder end. And now I find that the force required to detach the small piece of iron from the front end is about 3½ lbs., instead of 2½ lbs. The front end exerts a bigger pull when there is a mass of iron attached to the hinder end. Why? The whole iron core, including its front end, becomes more highly magnetized, because there is now a better way for the magnetic lines to emerge at the other end and come round to this. In short, we have diminished the magnetic reluctance of the air part of the magnetic circuit, and the flow of magnetic lines in the whole magnetic circuit is thereby improved. So it was also when the mass of iron was placed across the front end of the core; but the magnetic lines streamed away backwards from its edges; and few were left in front to act upon the small bit of iron. So the law of magnetic circuit action explains this anomalous behaviour. Facts like these have been well-known for a long time to those who have studied electromagnets. In Sturgeon's book there is a remark that bar-magnets pull better if they are armed with a mass of iron at the distant end, though Sturgeon did not see what we now know to be the explanation of it. The device of fastening a mass of iron to one end of an electromagnet in order to increase the magnetic power of the other end was patented by Siemens in 1862.

(To be continued.)

Miscellaneous.

EARLY FOREST OPERATIONS IN INDIA.

The following letter on early forestry operations in the Bombay and Madras Presidencies and Burmah addressed by General Michael to the Under-Secretary of State for India, has been forwarded to the Government of India:—

Bangor-lodge, Ascot,
June 14th, 1890.

To the Under-Secretary of State for India.

Sir,—With reference to your letter R. and S., 533, dated 3rd May, 1890, and to a letter from Mr. Danvers, R. and L., No. 656, of the 24th April, 1890, granting me permission to consult the early records of forest operations in India prior to the organisation of the present regular department, I have the honour to say that I have availed myself of the facilities given me, and have obtained a great deal of interesting information on the subject, which, in case it may be thought worthy of record, I have briefly summarised as follows.

The earliest efforts of all appear to have been made in Bombay, where the ship-building interest, creating a large demand for timber, naturally directed attention to the sources of supply. The Government, by Proclamation, assumed forest rights as far back as 1807, appointed Commissioners to fix boundaries, and attempted a scheme of conservancy, which, however, was abandoned in 1822. A letter from the Superintendent of the Indian Navy to the Bombay Government, dated 27th March, 1844, states that the Canara forests were under conservancy many years back, that Colonel Gilbert held the situation of Conservator for 16 years, that he was succeeded by Captain

Jackes, of the Indian Navy, who was withdrawn in 1823-24, when the establishment was broken up.

The report of the Bombay Forest Commission describes some further attempts, but nothing need be said of them until we get to the year 1840, when the late Dr. Alexander Gibson, Superintendent of the Botanical Gardens in Bombay, was deputed to examine and report on the northern forests of the Presidency; and in 1846 he was formally appointed Conservator of Forests in addition to his other botanical garden duties. Operations were immediately commenced on a very extensive scale—far too extensive for the times—in nearly every district of the Presidency. Dr. Gibson's principal duty was the provision of timber for the dockyard, where ships for the Royal Navy were then built, and it was largely purchased, through his agency, in Canara and Malabar. The collection and sale of building timber, firewood, and jungle produce was also attempted, and a stringent system of taxation on fuel and building wood was introduced throughout the Presidency, the collection of such taxes being made by the civil authorities and heads of villages. These innovations, clashing with the ancient rights of the people, seem to have aroused much opposition, and conservancy did not progress at all smoothly in the Bombay Presidency, either at this time or for many years afterwards. In Dr. Gibson's reports are found frequent allusions to petitions against his measures, and, on one occasion, he describes his personal danger from an excited mob. The operations, moreover, did not pay, and in 1851 the Military Board, under which Dr. Gibson worked, reported* that no profit was made; and one of the members of council (Mr. Blane) minuted thereon to the effect that it would be well to restrict the operations. Dr. Gibson, however, remained Conservator till 1860.

One of his efforts towards establishing conservancy was the introduction of a measure under which heads of villages and land holders were entrusted with the preservation and working of forest tracts, receiving a small share of any profit derived from them. Dr. Gibson, during his ten years tenure, and Dr. Stocks (who acted for Dr. Gibson during his absence in Europe, and who also did good work in Sind) were earnest and persistent in their advocacy of economy in forest matters and the preservation of their resources; and although their measures savoured too much of a timber trade, and a wholesale confiscation of ancient rights and customs, they rendered most valuable service to the cause of conservancy, which was then beginning to attract the serious attention of the Court of Directors.

As far back as in 1847, there was an officer denominated "Forest Ranger" in Sind. The appointment was held successively by Major Scott, Captain Crawford, and Dr. Stocks, later on by Captain Hamilton of the Indian Navy, and Mr. Dalziell. In the earlier days, the duties of the Ranger appear to have been to ensure a supply of fuel for the Indus flotilla, and to raise a revenue from grazing fees, firewood, and jungle produce. A small revenue was also obtained by the sale of such building wood as was obtainable; but the so-called forests of Sind contain little excepting babool (*Acacia arabica*), bahn (*Populus euphratica*), and "tamarisk" (*Tamarix orientalis*), and are thus described:—"Wood is scanty, brush being the rule, and wood the exception." A great deal of excellent work was done by the above officers, and the measures they took to prevent waste, and the views they enunciated on the subject of conservancy and reproduction, were most useful to the cause. But here again the establishment did not pay, and Dr. Gibson, in reporting on it in 1851, says, that though the forests defrayed the expenses of the native management, the salaries of the European officers remained a charge to the State.

About the year 1847, also, the late General John Jacob undertook planting operations in the arid part of the Upper Sind frontier. His main object was to create shade, and to improve the rainfall and climate; and I have been told by Sir Henry Green, who was with him at the time, and who remained in Sind for many years afterwards, that the effect on the rainfall especially had become very marked before he left the country.

The first attempts at protecting forests in the Tenasserim provinces date back to 1827, when Dr. Wallich reported on the teak forests, and proposed that the British Government should take steps for preserving them. Efforts were made to establish rules, and in 1833 a small native establishment was formed, under the control of the civil authorities. But as the rules framed were mainly in the interest of the State, which clashed with those of private enterprise, it was found that they could not be carried out, and they became a dead letter. Again, in 1837 and 1838, Dr. Helfer reported on them and, as a result, the executive engineer of Maulmain, Captain Tremenheere, was appointed Superintendent of Forests. In 1842 a code of rules for these forests was approved by the Government of India, but was disapproved by the Court of Directors. Again, in 1847, the late Mr. J. R. Colvin, then commissioner, attempted the formation of a forest department, but this also appears to have fallen through, for, in 1851, when the Madras Government deputed me to Maulmain to see whether anything could be learned from Burmese forest operations which could be turned to account in the Annamullays, I found that there was no forest officer or establishment, and the commissioner, Sir Archibald Bogle, could only hand me over to a European timber merchant, with whose assistance I visited the forests on the Attaran river, which he held on lease. After the second Burmese War, vast tracts of valuable forests fell into the possession of the State, and in 1853, Dr. McClelland was appointed Superintendent of Forests in Pegu, and reported on our new acquisitions. He remained there till 1856, when Dr. (now Sir Dietrich) Brandis was appointed to succeed him.

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* Bombay despatch to Court of Directors, No. 15, of 1852, enclosing Military Board's letter, No. 9905, of 1851.

As the Madras Presidency is rich in timber forests all along the Western Ghâts, from Canara to Cape Comorin, a great deal of the teak used in the Bombay dockyard was obtained from Malabar, Canara, and Coimbatore, as well as from Cochin and Travancore. In consequence of this enormous demand, and of the ruinous methods under which the forests were worked by the lessees, a threatened scarcity of teak arose, and in 1843 the late Mr. H. V. Conolly began an experimental plantation at Nilambur, in Malabar. His success having been appreciated by the Madras Government, the work was gradually extended, with the result that, at the present day, there is a magnificent artificial forest of teak in that district, the value of which can hardly be over-estimated. At the Edinbugh Forestry Exhibition of 1884, I had 33 sections of teak trees which were reared in these plantations, and represented the growth of each year between 1844 and 1876. The largest of these sections was taken from the 1847 plantation, from a tree 36 years old, measuring 103 feet in height and 8 ft. 4 in. in girth.

But little or nothing of a practical nature was done at that time towards preserving the natural forests of the Madras Presidency. Large tracts were leased at nominal rates to timber merchants, whose wasteful operations ruined many forests past redemption ; nor was any wholesome restriction put on the clearing of forest land for cultivation in localities where it was desirable to retain it. In 1847, however, at the earnest recommendation of Captain (now Major-General) Frederick Cotton, the Government took determined action in the matter, and resolved to take one of the most valuable tracts into their own hands. Accordingly, in 1848, they appointed a special officer (myself), with a small establishment, to take charge of the Annamullay forests, in the Coimbatore district ; and to this they shortly afterwards added a large adjoining tract, which they acquired on lease from a neighbouring zemindar. The whole was thus put under careful conservancy, and at the same time the working of both forests was undertaken and carried out on economical and reasonable principles.

Roads and a timber slip were made ; axemen, sawyers, carters, and other workmen were imported from the adjacent districts ; while the hill people were employed as much as possible on work for which they were fitted—such as clearing brushwood and grass round saplings and girdled trees in the fire season, hutting the workmen, &c., &c.

The locality of this experimental work was one not much hampered with ancient communal rights ; but such as existed were respected, and compensation was paid for unexpired leases. Consequently, in spite of some obstruction on the part of a few merchants, who had had the free run of the forests, and on the part of the native official who was supposed to supervise them, under the title of "Conservator"—and who was the worst bandit of all—things went pretty smoothly, and there was no friction with the village authorities or people. The dockyard timber which was brought out was floated by river to the coast for shipment to Bombay, and supplies of teak and other timber were sent to the Madras Gun Carriage Manufactory, and to the Nilghiri Barrack Works ; and thus not only was wasteful working and depredation checked and conservancy introduced, but in a few years all the initial expense had been wiped off, and a good financial result had been achieved, as was acknowledged by the Court of Directors in 1854* in handsome terms.

The Madras Government, however, in reporting the success of their experimental work, enunciated the principle which they have frequeutly since affirmed, that conservancy of forest resources was, and should be, the primary consideration, and the acquisition of revenue a secondary one. In 1851, a Committee of the British Association for the Advancement of Science did opportune service to the cause by drawing attention in England to the urgent need of extending forest conservancy in India, alluding to the fact that, where supervision had been exercised, improvement had taken place.

In 1855, my health broke down, and I had to give up the work. I was succeeded by Captain (now General) Douglas Hamilton, and, in the following year, the Madras Government felt justified in extending, to other parts of the Presidency, operations which had been working satisfactorily for eight years in one district. In short, they determined to organise a small forest department, and, in 1856, Dr. Hugh Cleghorn was appointed Conservator of Forests, with Captain Douglas Hamilton, Lieut. Beddome, and Dr. Drew as his assistants, with a suitable subordinate establishment, the whole costing 5,000 rupees a month. Within the next few years Dr. Cleghorn was able without difficulty to introduce conservancy and working, similar to that of the Annamullays, into several other districts—Salem, Malabar (Wynaad), Canara, and the Northern Circars, and, subsequently, into every district of the Presidency. The wisdom of having begun in one district only, and of not attempting too much till a fair footing was obtained, was very apparent when an extension of the measures was desired, and it proved afterwards that, if judiciously introduced, conservancy could be carried out without irritating the people, and, indeed, with their friendly co-operation. The absence of opposition has been a marked feature of forest administration in Madras ever since. A high compliment was paid to the success of the above early operations, when the Government of India, in 1861, sought the aid of the Madras Conservator to put them in the way of establishing an efficient system of conservancy and work in the Punjab and North-Western Provinces, and to aid Sir D. Brandis, when he was called up from Burmah, in 1862, in commencing the organisation of the Imperial Forest Department, of which Sir D. Brandis was appointed Inspector-General in 1864.

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* Financial Despatch, No. 15, of 1854.

Nothing worthy of mention was done in the provinces under the direct control of the Government of India till about the year 1860. A despatch from the Government of India to the Secretary of State, No. 75, of 1862, briefly describes the then existing state of affairs, and advocates the propriety of organising a regular Forest Department. After mentioning that both Madras and Bombay had organised forest establishments, with which the Government of India had "abstained from any sensible interference," and regarding which they did not suggest any change, the despatch goes on to say:—"In Bengal, till now, nothing has been done, and a sufficient comment on this neglect will be found in the fact that it is necessary to import railway sleepers from Norway."

In Oude, "Nothing was done till the re-occupation of the province."

In the North-Western Provinces:—"The difficulty of obtaining timber has been painfully felt for the last fifteen years or more, but the administration of the forests there up to the time of the mutinies was a melancholy failure."

In the Punjab, and along the slopes of the Himalayas, nothing was done till 1861, when Dr. Cleghorn was borrowed from Madras and deputed there.

In the Central Provinces a Superintendent was appointed in 1860:—"But here also operations are based on almost ruined forests"—sad words!

In Hyderabad assigned districts work was "just being organised."

From the Straits Settlements, "No question relating to forests had come before the Government of India."

In Mysore:—"Some first steps have been taken to establish a system of conservancy, but they call for no special comment." I can say, however, from my own knowledge, that, so far back as 1847-48, several officers of the then Mysore Commission, notably Colonel Onslow, Major Martin, and Dr. Cleghorn—as well as Messrs. Blane, Fisher, and Maltby in Canara—did valuable service in the direction of conservancy, by raising their voices against the destructive cultivation called "Coomri," prevalent all along the Western Ghats.

This brief *précis* is sufficient for my present purpose, and may be of interest to those who survive of the officers who aided in or watched the inception of forest conservancy in India.

I have the honour to be, Sir,
Your most obedient servant,
J. MICHAEL,
Major-General.

Obituary.

CANON LIDDON.—Canon Liddon, whose death on the 9th inst., at the age of 61 years, has been announced, became a member of the Society in 1888. The accounts of Canon Liddon's life and work which have appeared in the daily papers render it unnecessary to do more than put on record the fact of his connection with this Society.

PICKERING PHIPPS.—Mr. Pickering Phipps, formerly Conservative member of Parliament for the borough of Northampton, and afterwards for South Northamptonshire, died at his residence, Collingtree, Northamptonshire, on Sunday, 7th inst., aged 68. Mr. Phipps was the senior partner in the firm of Phipps and Son, brewers, Northampton and Towcester. He was a member of the Northampton Town Council for 30 years, and was twice elected mayor of the borough. Mr. Phipps was a member of the Society of Arts from 1874.

General Notes.

JARRAH WOOD.—The last number of the *Kew Bulletin* contains a note on the properties and uses of the jarrah wood, a species of eucalyptus, native to Western Australia. The main difficulties in connection with its use in this country are the cost of freight for such heavy timber from Australia and its intense hardness, which makes it difficult for ordinary English carpenters' tools to work it. The tree which produces it grows generally to a height of 100 feet, and sometimes 150 feet. It is found only in Western Australia, extending over the greater portion of the country from the Moore River to King George's Sound, forming mainly the forests of these tracts. According to Baron Mueller, when selected from hilly localities, cut while the sap is least active, and subsequently carefully dried, it proves impervious to the borings of insects. Vessels constructed solely of it have, after 25 years' constant service, remained perfectly sound, although not coppered. It has been tried at three places in the Suez Canal, and after having been down seven years, the trial samples were taken up in order that a report on their condition might be sent to Paris. From certain correspondence between Kew and some London vestries, it appears that jarrah has lately been used by the Chelsea Vestry for paving the King's-road, and by the Lambeth Vestry in the Westminster-bridge-road.

Journal of the Society of Arts.

No. 1,975. Vol. XXXVIII.

FRIDAY, SEPTEMBER 26, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

EXAMINATIONS, 1891.

The subjects of examination are—1. Arithmetic; 2. English (including composition and correspondence, and précis writing); 3. Book-keeping; 4. Commercial Geography; 5. Shorthand; 6. Type-writing; 7. French; 8. German; 9. Italian; 10. Spanish; 11. Portuguese; 12. Russian; 13. Danish; 14. Chinese; 15. Japanese; 16. Political Economy; 17. Domestic Economy; 18. Theory of Music; 19. Practice of Music.

These examinations will be held on March 16, 17, 18, and 19, with the exception of that in the Practice of Music, which will be held during the week commencing on the 1st of June.

In addition to the syllabus of examinations, the Programme contains an appendix giving the questions set in 1890, and the reports of the examiners on the papers worked.

The Programme is now ready. Copies can be obtained gratis on application to the Secretary.

PRIZES FOR DESIGNS FOR FURNITURE.

The Council of the Society of Arts hold a sum of £400, the balance of the subscriptions to the Owen Jones Memorial Fund, presented to them by the Memorial Committee, on condition of their spending the interest thereof in prizes to "Students of the Schools of Art, who in annual competition produce the best designs for Household Furniture, Carpets, Wall-papers and Hangings, Damasks, Chintzes, &c., regulated by the principles laid down by Owen Jones."

The prizes will be awarded on the results of the Annual Competition of the Science and Art Department. Competing designs must be marked, "In competition for the Owen Jones Prizes."

No candidate who has gained one of the above prizes can again take part in the competition.

The next award will be made in 1891, when six prizes are offered for competition, each prize to consist of a bound copy of Owen Jones' "Principles of Design," and the Society's Bronze Medal.

Proceedings of the Society.

CANTOR LECTURES.

THE ELECTROMAGNET.

By Professor Silvanus P. Thompson,
D.Sc., B.A., M.I.E.E.

Lecture II.—Delivered January 27th, 1890.

(*Continued from p.* 905.)

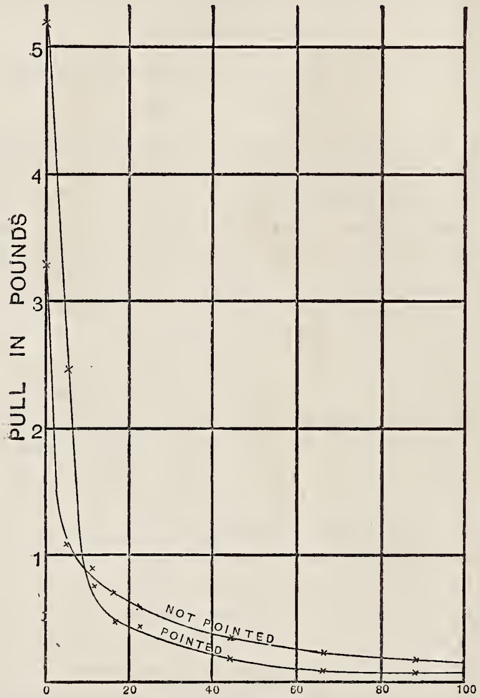
We are now in a position to understand the bearing of some curious and important researches made about forty years ago by Dr. Julius Dub, which, like a great many other good things, lie buried in the back volumes of Poggendorff's "Annalen." Some account of them is also given in Dr. Dub's now obsolete book, entitled "Elektromagnetismus."

The first of Dub's experiments to which I will refer relates to the difference in behaviour between electromagnets with flat and those with pointed pole ends. He formed two cylindrical cores, each six inches long, from the same rod of soft iron, one inch in diameter. Either of these could be slipped into an appropriate magnetizing coil. One of them had the end left flat, the other had its end pointed, or, rather, it was coned down until the flat end was left only $\frac{1}{2}$ inch in diameter, possessing therefore only one-fourth of the amount of contact surface which the other core possessed. As an armature there was used another piece of the same soft iron rod, twelve inches long. The pull of the electromagnet on the armature at different distances was carefully measured, with the following results:—

Distance apart in inches.	Pull on Flat Pole (lbs.).	Pull on Pointed Pole (lbs.).
0	3·3	5·2
0·0055	1·1	1·8
0·0110	0·9	0·75
0·0165	0·71	0·50
0·022	0·60	0·42
0.044	0·38	0·20
0·088	0·19	0·09

These results are plotted out in the curves in Fig. 35. It will be seen that in contact, and at very short distances, the reduced pole gave the greater pull. At about ten mils distance there was equality, but at all distances greater than ten mils the flat pole had the advantage. At small distances the concentration of magnetic lines gave, in accordance with the law of traction, the advantage to the reduced pole. But this advantage was, at the greater distances, more than outweighed by the fact that with the greater widths of air-gap the use of the pole with larger face reduced the magnetic reluctance of the gap and promoted a larger flow of magnetic lines into the end of the armature.

FIG. 35.



CONTRASTED EFFECT OF FLAT AND POINTED POLES.

Dub's next experiments relate to the employment of polar extensions or pole-pieces attached to the core. These experiments are so curious, so unexpected, unless you know the reasons why, that I invite your especial attention to them. If an engineer had to make a firm joint between two pieces of metal, and he feared that a mere attachment of one to the other was not adequately strong, his first and most natural impulse is to enlarge the parts that come together—to give one as it were a broader footing against the other. And that is precisely what an engineer, if uninstructed in the true principles of magnetism, would do in order to make an electromagnet stick more tightly on to its armature. He would enlarge the ends of one or both. He would add pole pieces to give the armature a better foothold. Nothing, as you will see, could be more disastrous. Dub employed in these experiments a straight electromagnet having a cylindrical soft-iron core, 1 inch in diameter, 12 inches long; and as armature a piece of the same iron, 6 inches long. Both were flat-ended. Then six pieces of soft iron were prepared of various sizes, to serve as pole-pieces. They could be screwed on at will either to the end of the magnet core or to that of the armature. To distinguish them we will call them by the letters A, B, C, &c. Their dimensions were as follows, the inches being presumably Bavarian inches:—

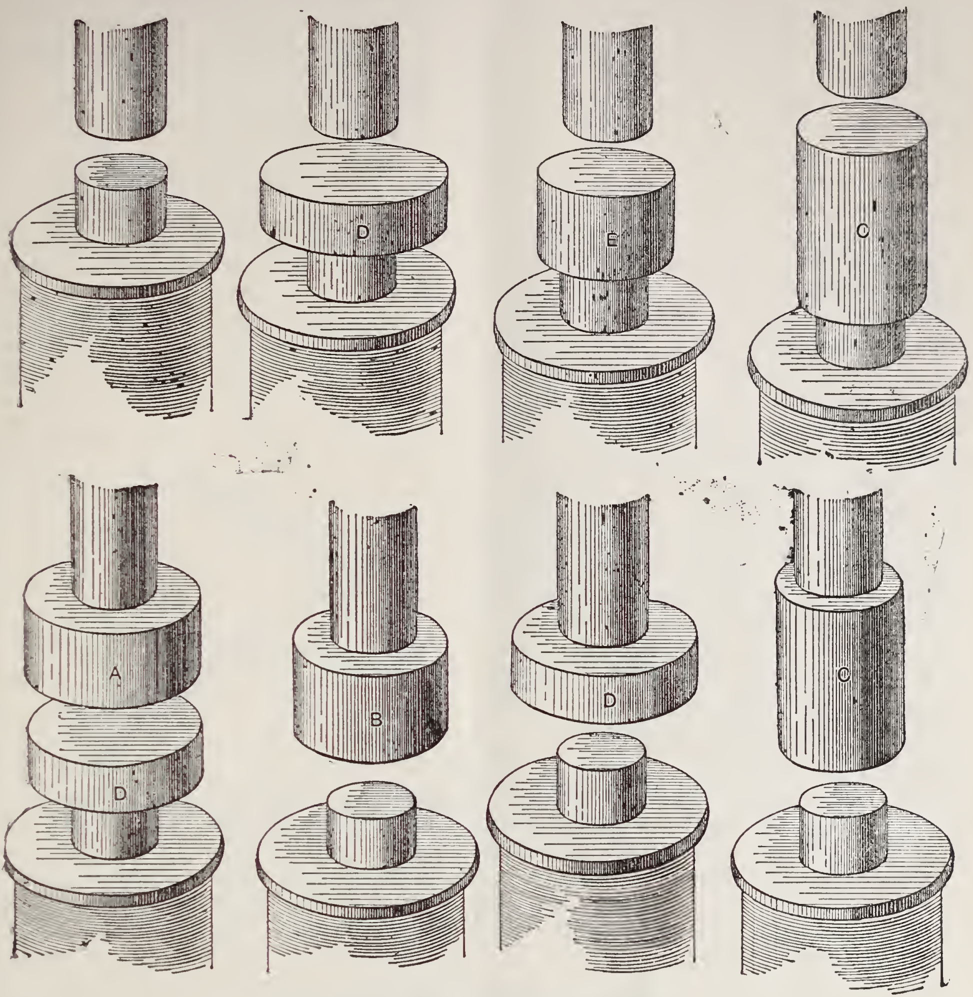
Piece.	Diameter.	Length.
	inches.	inches.
A	2	1
B	1¾	1¼
C	1⅜	2
D	2	½
E	1½	1
F	1	2

Of the results obtained with these pieces we will select eight. They are those illustrated by the eight collected sketches in Fig. 36. The pull required to detach was measured, also the attraction exerted at a certain distance apart.

Experiment.	On Magnet.	On Armature.	Traction.	Attraction.
I.	none	none	48	22
II.	D	none	30	10
III.	E	none	32	11·5
IV.	C	none	35	13·5
V.	D	A	20	7·5
VI.	none	B	50	25
VII.	none	D	43	25
VIII.	none	C	50	18

It will be noted that, in every case, putting on a pole-piece to the end of the magnet diminished both the pull in contact and the attraction at a distance; it simply promoted leakage and dissipation of the magnetic lines.

Fig. 36.

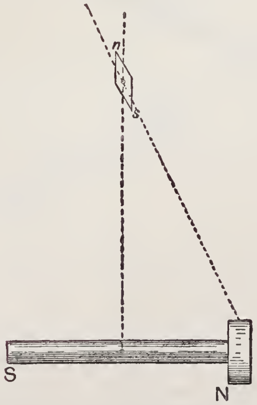


Dub's Experiments with Pole-pieces.

The worst case of all was that in which there were pole pieces both on the magnet and on the armature. In the last three cases the pull was increased, but here the enlarged piece was attached to the armature, so that it helped those magnetic lines which came up into it to flow back laterally to the bottom end of the electromagnet, while thus reducing the magnetic reluctance of the return path through the air, and so increasing the total number of magnetic lines, did not spread unduly those that issued up from the end of the core.

The next of Dub's results relate to the effect of adding these pole-pieces to an electro-magnet 12 inches long, which was being employed, broadside-on, to deflect a distant compass needle (Fig. 37).

Fig. 37.



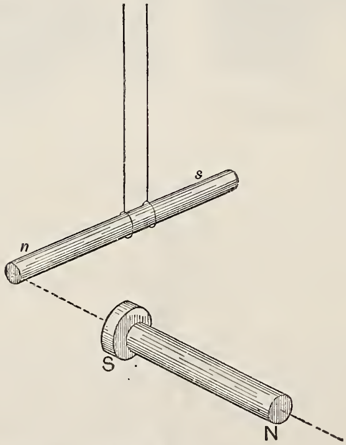
Dub's Deflexion Experiment.

Pole-piece used.	Deflexion (degrees).
none	34·5
A	42
B	41·5
C	40·5
D	41
E	39
F	38

In another set of experiments of the same order a permanent magnet of steel, having poles *n s*, was slung horizontally by a bifilar suspension, to give it a strong tendency to set in a particular direction. At a short distance laterally was fixed the same bar electro-magnet, and the same pole-pieces were again employed. The results of attaching the pole-pieces at the rear end are not very conclusive; they slightly increased the deflexion. But in the absence of information as to the distance between the steel magnet and the electro-magnet, it is difficult to assign proper values to all the causes at work. The results were:—

Pole-piece used.	Deflexion (degrees).
none	8·5
A	9·2
B	9·5
C	10
D	8·8

Fig. 38.

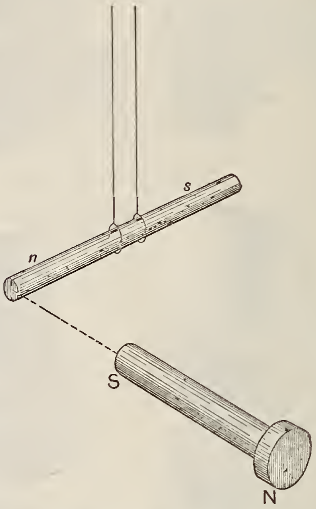


Deflecting a Steel Magnet having Bifilar Suspension, Pole-piece on Near end.

When, however, the pole-pieces were attached to the distant end of the electro-magnet, where their effect would undoubtedly be to promote the leakage of magnetic lines into the air at the front end without much affecting the distribution of those lines in the space in front of the pole, the action was more marked.

Pole-piece used.	Deflexion (degrees).
none	8·5
A	10·0
B	10·3
C	10·3
F	10·1

Fig. 39.



Deflecting Steel Magnet, Pole-piece on Distant end.

Still confining ourselves to straight electro-magnets, I now invite your attention to some experiments made in 1862 by the late Count Du Moncel as to the effect of adding a polar expansion to the iron core. He used as his core a small iron tube, the end of which he could close up with an iron plug, and around which he placed an iron ring which fitted closely on to the pole. He used a special lever arrangement to measure the attraction exercised upon an armature distant in all cases one millimetre from the pole. The results were as follows:—

	Without ring on pole.	With ring on pole.
Tubular core alone	11	10
ditto, with iron plug	17	14
Core provided with mass of iron at distant end	27	25
ditto, ditto, with iron plug	38	33

After hunting up these researches, it was extremely interesting to find that so important a fact had not escaped the observant eye of the original inventor of the electromagnet. In Sturgeon's "Experimental Researches" (p. 113) there is a footnote, written apparently about the year 1832, which runs as follows:—

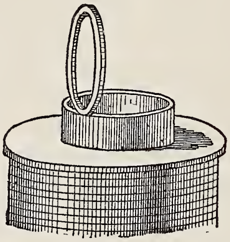
> "An electromagnet of the above description, weighing three ounces, and furnished with one coil of wire, supported fourteen pounds. The poles were afterwards made to expose a larger surface by welding to each end of the cylindric bar a square piece of good soft iron; with this alteration only the lifting power was reduced to about five pounds, although the magnet was annealed as much as possible."

We saw that this straight electromagnet, whether used broadside-on or end-on, could act on the compass needle at some distance from it, and deflect it. In those experiments there was no return-path for the magnetic lines that flowed through the iron core save that afforded by the surrounding air. The lines flowed round in wide-sweeping curves from one end to the other, as in Fig. 26; the magnetic field being quite extensive. Now, what will happen if we provide a return path? Suppose I surround the electromagnet with an iron tube of the same length as itself, the lines will flow along in one direction through the core, and will find an easy path back along the outside of the coil. Will the magnet thus jacketted pull more powerfully or less on that little suspended magnet? I should expect it to pull less powerfully, for if the magnetic lines have a good return path here through the iron tube, why should they force themselves in such a quantity to a distance through air in order to get home? No, they will naturally return short back from the end of the core into the tubular iron jacket. That is to say, the action at a distance ought to be diminished by putting on that iron tube outside. Here is the experiment set up. And you see that when I turn on the current my indicating needle is scarcely affected at all. The iron jacket causes that magnet to have much *less* action at a distance. Yet I have known people who actually proposed to use jacketted magnets of this sort in telegraph instruments, and in electric motors, on the ground that they give a bigger pull. You have seen that they produce less action at a distance across air, but there yet remains the question whether they give a bigger pull in contact? Yes, undoubtedly they do; because everything that is helping the magnetism to get round to the other end increases the goodness of the magnetic circuit, and therefore increases the total magnetic flux.

We will try this experiment upon another piece of apparatus, one which has been used for some years at the Finsbury Technical College. It consists of a straight electromagnet set upright in a base-board, over which is erected a light gallows of wood. Across the frame of the gallows goes a winch, on the axle of which is a small pulley with a cord knotted to it. To the lower end of the cord is hung a common spring balance, from the hook of which depends a small horizontal disk of iron to act as an armature. By means of the winch I lower this disk down to the top of the electromagnet. The current is turned on; the disk is attracted. On winding up the winch I increase the upward pull until the disk is detached. See, it required about 9 lbs. to pull it off. I now slip over the electromagnet, without in any way attaching it, this loose jacket of iron—a tube, the upper end of which stands flush with the upper polar surface. Once more I lower the disk, and this time it attaches itself at its middle to the central pole, and at its edges to the tube. What force will now be required to detach it? The tube weighs about ½ lb., and it is not fixed at the bottom. Will 9½ lbs. suffice to lift the disk? By no means. My balance only measures up to 24 lbs., and even that pull will not suffice to detach the disk. I know of one case where the pull of the straight core was increased 16-fold by the mere addition of a good return-path of iron to complete the magnetic circuit. It is curious how often the use of a tubular jacket to an electromagnet has been re-invented. It dates back to about 1850, and has been variously claimed for Romershausen, for Guillemin, and for Fabre. It is described in Davis's "Magnetism," published in Boston in 1855. About 16 years ago Mr. Faulkner, of Manchester, revived it, under the name of the *Altandae* electromagnet. A discussion upon jacketted electromagnets took place in 1876, at the Society of Telegraph Engineers; and in the same year, Professor Graham Bell used the same form of electromagnet in the receiver of the telephone which he exhibited at the Centennial Exhibition. But the jacketted form is not good for anything except increasing the tractive power. Jacketting an electromagnet which already possesses a return circuit of iron is an absurdity. For this reason the proposal made by one inventor to put iron tubes outside the coils of a horseshoe electromagnet is one to be avoided.

We will take another paradox, which equally can be explained by the principle of the magnetic circuit. Suppose you take an iron tube as an interior core; suppose you cut a little piece off the end of it; a mere ring of the same size. Take that little piece and lay it down on the end. It will be struck with a certain amount of pull. It will pull off easily. Take that same round piece of iron, put it on edgewise, where it only touches one point of the circumference, and it will stick on a good deal tighter, because it is there in a position to increase the magnetic flow of the magnetic lines. By concentrating the flow of magnetic lines over a small surface of contact increases **B** at that point, and $\mathbf{B}^2$, integrated over the lesser area of the contact, gives a total bigger pull than is the case when the edge is touched all round against the edge of the tube.

Fig. 40.

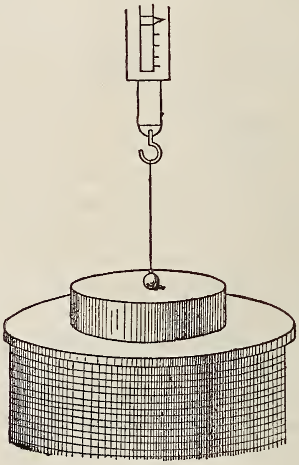


Experiment with Tubular Core and Iron Ring.

Here is a still more curious experiment. I use a cylindrical electromagnet set up on end, the core of which has at the top a flat circular polar surface about two inches in diameter. I now take a round disk of thin iron—ferrotype or tin-plate will answer quite well—which is a little smaller than the polar face. What will happen when this disk is laid down flat and centrally on the polar face? Of course you will say that it will stick tightly on. If it does so, the magnetic lines which come in through its under surface will pass through it and come out on its upper surface in large quantities. It is clear that they cannot all, or even any considerable proportion of them, emerge sideways through the edges of the thin disk, for there is not substance enough in the disk to carry so many magnetic lines. As a matter of fact the magnetic lines do come through the disk, and emerge on its upper surface, making indeed a magnetic field over its upper surface that is nearly as intense as the magnetic field beneath its under surface. If the two magnetic fields were exactly of equal strength, the disk ought not to be attracted either way. Well, what is the fact? The fact, as you see now that the current has been turned on, is that the disk absolutely refuses to lie down on the top of the pole. If I hold it down with my finger, it actually bends itself up, and requires force to keep it down. I lift my finger, and over it flies. It will go anywhere in its effort to better the magnetic circuit rather than lie flat on the top of the pole.

Next I invite your attention to some experiments, originally due to Von Kolke, published in the "Annalen" forty years ago, respecting the distribution of the magnetic lines where they emerge from the polar surface of an electromagnet. I cannot enumerate them all, but will merely illustrate them by a single example. Here is a straight electromagnet with a cylindrical, flat-ended core (Fig. 41). In what way will the magnetic lines be distributed over at the end? Fig. 41 illustrates roughly the way in which, when there is no return-path of iron, the magnetic lines leak through the air. The main leakage is through the ends, though there is some at the sides also. Now the question of the end-distribution we shall try by using a small bullet of iron, which will be placed at different points from the middle to the edge, a spring balance being employed to measure the force required to detach it. The pull at the edge is much stronger than at the middle, at least four or five times as great. There is a regular increase of pull from the middle to the edge. The magnetic lines, in trying to complete

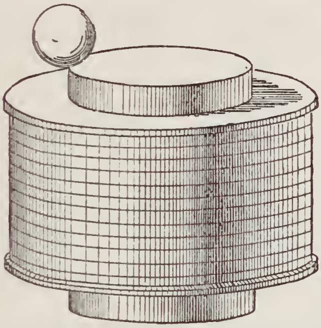
Fig. 41.



Exploring Polar Distribution with small Iron Ball.

their own circuit, flow most numerously in that direction where they can go furthest through iron on their journey. They leak out more strongly at all edges and corners of a polar surface. They do not flow out so strongly at the middle of the end surface, otherwise they would have to go through a larger air-circuit to get back home. The iron is consequently more saturated round the edge than at the middle; therefore, with a very small magnetizing force, there is a great disproportion between pull at the middle and that at the edges. With a very large magnetizing force you do not get the same disproportion, because if the edge is already far saturated you cannot by applying higher magnetizing power increase its magnetization much, but you can still force more lines through the middle. The consequence is, if you plot out the results of a succession of experiments of the pull at different points, the curves obtained are, with larger magnetizing forces, more nearly straight than are those obtained with small magnetizing forces. I have known cases where the pull at the edge was six or seven times as great as in the middle with a small magnetizing power, but with larger power not more than two or three times as great, although of course the pull all over was greater. You can easily observe this distribution by merely putting a polished iron ball upon the end of the electromagnet, as in Fig. 42. The ball at once rolls to the edge and will not stay at the middle. If I take a larger two-pole electromagnet (like Fig. 11) what will the case now be? Clearly the shortest path of the magnetic lines through the air is the path just across from the edge of one polar surface to the edge of the other between the poles. The lines are most dense in the region where they arch over in as short an arch as possible, and they will be less dense along the longer paths, which arch more widely over. Therefore, as there is a greater tendency to leak from the inner edge of one pole to the inner edge of the other, and less tendency to leak from the outer edge of one to the outer edge of the other, the biggest pull ought to be on the inner edges of the pole. We will now try it. On putting the iron ball anywhere on the pole it immediately rolls until it stands perpendicularly over the inner edge.

Fig 42.

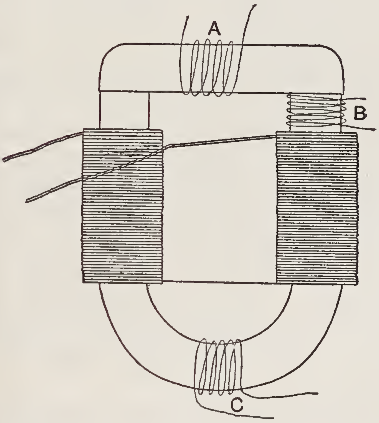


Iron Ball Attracted to Edge of Polar Face.

The magnetic behaviour of little iron balls is very curious. A small round piece of iron does not tend to move at all in the most powerful magnetic field if that magnetic field is uniform. All that a small ball of iron tends to do is to move from a place where the magnetic field is weak to a place where the magnetic field is strong. Upon that fact depends the construction of several important instruments, and also certain pieces of electromagnetic mechanism.

In order to study this question of leakage, and the relation of leakage to pull, still more incisively, I devised some time ago a small experiment with which a group of my students at the Technical College have been diligently experimenting. Here (Fig. 43) is a horseshoe electromagnet. The core is of soft wrought iron, wound with a known number of turns of wire. It is provided with an armature. We have also wound on three little exploring coils, each consisting of five turns of wire only, one, C, right down at the bottom, on the bend; another, B, right round the pole,

Fig. 43.



Experiment on Leakage of Electromagnet.

close up to the armature; and a third, A, around the middle of the armature. The object of these is to ascertain how much of the magnetism which was created in the core by magnetizing power of these coils ever got into the armature. If the armature is at a considerable distance away, there is naturally a great deal of leakage. The coil, C, around the bend at the bottom is to catch all the magnetic lines that go through the iron; the coil, B, at the poles is to catch all that have not leaked outside before the magnetism has crossed the joint; while the coil, A, right around the middle of the armature, catches all the lines that actually pass into the armature and pull at it. We measure by means of the ballistic galvanometer and these three exploring coils how much magnetism gets into the armature at different distances, and are able thus to determine the leakage and compare these amounts with the calculations made, and with the attractions at different distances. The amount of magnetism that gets into the armature does not go by a law of inverse squares, I can assure you, but by quite other laws. It goes by laws which can only be expressed as particular cases of the law of the magnetic circuit. The most important element of the calculations, indeed, in many cases is the amount of per-centage of leakage that must be allowed for. Of the magnitude of this matter you will get a very good idea by the result of these experiments following.

The iron core is 13 millimetres in diameter, and the coil consists of 178 turns. The first swing of the galvanometer when the current was suddenly turned on or off measures the number of magnetic lines thereby sent through, or withdrawn from, the exploring coil that is at the time joined to the galvanometer. The currents used varied from 0·7 of an ampere to 5·7 amperes. Six sets of experiments were made, with the armature at different distances. The numerical results are given below:—

I.—WITH WEAK CURRENT (0·7 AMPERES).

		A	B	C
In contact		12,506	13,870	14,190
Armature distance.	1 mm	1,552	2,163	3,786
	2 mm	1,149	1,487	2,839
	5 mm	1,014	1,081	2,028
	10 mm	676	1,014	1,690
Removed		—	675	1,352

II.—STRONGER CURRENT (1·7 AMPERES).

		A	B	C
In contact		18,240	19.590	20,283
Armature distance.	1 mm	2,570	3,381	5,408
	2 mm	2,366	2,839	5,073
	5 mm	1,352	2,299	5,949
	10 mm	811	1,352	3,381
Removed		—	1,308	3,041

III.—STILL STRONGER CURRENT (3·7 AMPERES).

		A	B	C
In contact		20,940	22,280	22,960
Armature distance.	1 mm	5,610	7,568	11,831
	2 mm	4,597	6,722	9,802
	5 mm	2,569	3,245	7,436
	10 mm	1,149	2,704	7,098
Removed		—	2,366	6,427

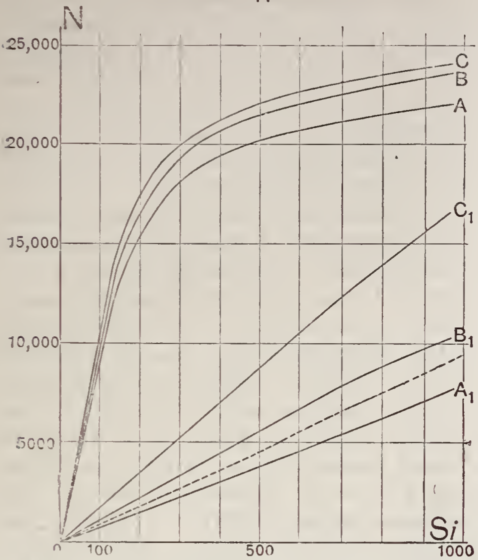
IV.—STRONGEST CURRENT (5·7 AMPERES).

		A	B	C
In contact		21,980	23,660	24,040
Armature distance.	1 mm	8,110	10,810	17,220
	2 mm	5,611	8,464	15,886
	5 mm	4,056	5,273	12,627
	10 mm	2,029	4,057	10,142
Removed		—	3,581	9,795

These numbers may be looked upon as a kind of numerical statement of the facts roughly depicted in Figs. 31 to 34, on p. 903-4. The numbers themselves, so far as they relate to the measurements made (1) in contact, (2) with gaps of one millimetre breadth, are plotted out on Fig. 44; there being three curves, A, B, and C, for the measurements made when the armature was in contact, and three others, A_1, B_1, C_1, made at the one millimetre distance. A dotted line gives the plotting of the numbers for the coil C, with different currents, when the armature was removed.

On examining the numbers in detail we observe that the largest number of magnetic lines forced round the bend of the iron core, through the coil C, was 24,040 (the cross-section being a little over 1 square centimetre), which was when the armature was in contact. When the armature was away, the same magnetizing power only evoked 9,795 lines. Further, of those 24,040, 23,660 (or 98½ per

Fig. 44.



Curves of Magnetization Plotted from Preceding.

cent.) came up through the polar surfaces of contact, and of those again 21,980 (or 92½ per cent. of the whole number) passed through the armature. There was leakage, then, even when the armature was in contact, but it amounted to only 7½ per cent. Now, when the armature was moved but 1 millimetre (*i.e.*, $\frac{1}{25}$ inch) away, the presence of the air gaps had this great effect, that the total magnetic flux was at once choked down from 24,040 to 17,220. Of that number only 10,810 (or 61 per cent.) reached the polar surfaces, and only 8,110 (or 47 per cent. of the total number) succeeded in going through the armature. The leakage in this case was 53 per cent! With a 2 millimetre gap, the leakage was 65 per cent. when the strongest current was used. It was 68 per cent. with a 5 millimetre gap, and 80 per cent. with a 10 millimetre gap. It will further be noticed that whilst a current of 0·7 ampere sufficed to send 12,506 lines through the armature when it was in contact, a current 8 times as strong could only succeed in sending 8,110 lines when the armature was distant by a single millimetre.

Such an enormous diminution in the magnetic flux through the armature consequent upon the increased reluctance and increased leakage occasioned by the presence of the air-gaps, proves how great is the reluctance offered by air, and how essential it is to have some practical rules for calculating reluctances and estimating leakages to guide us in designing electromagnets to do any given duty.

The calculation of magnetic reluctances of definite portions of a given material are now comparatively easy, and, thanks to the formulæ of Professor Forbes, it is now possible in certain cases to estimate leakages. Of these methods of calculation an abstract will be given in the appendix to this lecture. I have, however, found Forbes's rules, which were intended to aid the design of dynamo-machines, not very convenient for the common cases of electromagnets, and have therefore cast about to discover some more apposite mode of calculation. To predetermine the probable percentage of leakage one must first distinguish between those magnetic lines which go usefully through the armature (and help to pull it) and those which go astray through the surrounding air and are wasted so far as any pull is concerned. Having set up this distinction, one then needs to know the relative magnetic conductance, or *permeance*, along the path of the useful lines and that along the innumerable paths of the wasted lines of the stray field. For (as every electrician accustomed to the problems of shunt circuits will recognise) the quantity of lines that go respectively along the useful and wasteful paths will be directly proportional to the conductances (or permeances) along those paths, or will be inversely proportional to the respective resistances along those paths. It is customary in electromagnetic calculations to employ a certain coefficient of allowance for leakage, the symbol for which is v, such that when we know the number of magnetic lines that are wanted to go through the armature we must allow for v times as many in the magnet core. Now, if u represents permeance along the useful path, and w the permeance of all the waste paths along the stray field, the total flux will be the useful flux as $u + w$ is to u. Hence the coefficient of allowance for leakage v, is equal to $u + w$ divided by u. The only real difficulty is to calculate u and w. In general u is easily calculated, it is the reciprocal of the sum of all the magnetic reluctances along the useful path from pole to pole. In the case of the electromagnet used in the experiments last described, the magnetic reluctances along the useful path are three in number, that of the iron of the armature, and those of the two air gaps. The following formula is applicable,

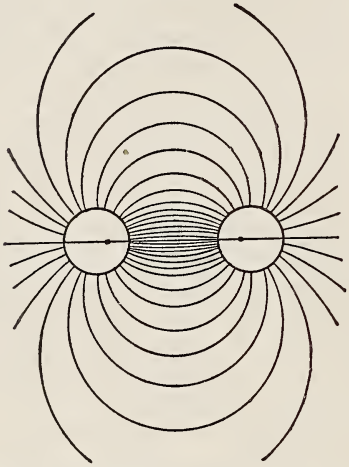
$$\text{reluctance} = \frac{l_1}{A_1 \mu_1} + \frac{2 l_2}{A_2},$$

if the data are specified in centimetre measure; the suffixes 1 and 2 relating respectively to the iron and to the air. If the data are specified in inch measures the formula becomes

$$\text{reluctance} = 0{\cdot}3132 \left\{ \frac{l''_1}{A''_1 \mu_1} + \frac{2l''_2}{A''_2} \right\}$$

But it is not so easy to calculate the reluctance (or its reciprocal, the permeance) for the waste lines of the stray field, because the paths of the magnetic lines spread out so extraordinarily and bend round in curves from pole to pole.

Fig. 45.



Curves of Flow of Magnetic Lines in Air from one Cylindrical Pole to another.

Fig. 45 gives a very fair representation of the spreading of the lines of the stray field that leaks across between the two limbs of a horse-shoe electromagnet made of round iron. And for square iron the flow is much the same, except that it is concentrated a little by the corners of the metal. Forbes's rules do not help us here. We want a new mode of considering the subject.

The problems of flow, whether of heat, electricity, or of magnetism, in space of three dimensions, are not amongst the most easy of geometrical exercises. However, some of them have been worked out, and may be made applicable to our present need. Consider, for example, the electrical problem of finding the resistance which an indefinitely extended liquid (say a solution of sulphate of copper of given density) offers when acting as a conductor of electric currents flowing across between two indefinitely long parallel cylinders of copper. Fig. 45 may be regarded as representing a transverse section of such an arrangement, the sweeping curves representing lines of flow of current. In a simple case like this it is possible to find an accurate expression for the resistance (or for the conductance) of a layer or stratum of unit thickness. It depends on the diameters of the cylinders, on their distance apart, and on the specific conductivity of the medium. It is not by any means proportional to the distance between them, being, in fact, almost independent of the distance, if that is greater than twenty times the perimeter of either cylinder. Neither is it even approximately proportional to the perimeter of the cylinders except in those cases when the shortest distance between them is less than a tenth part of the perimeter of either. The resistance, for unit length of the cylinders, is, in fact, calculated out by the rather complex formula:—

$$R = \frac{1}{\pi\mu} \text{ log. nat. } h \,;$$

Where

$$h = \frac{2a}{b + 2a - \sqrt{b^2 + 4\,ab}}\,;$$

the symbol a standing for the radius of the cylinder; b for the shortest distance separating them; μ for the permeability, or in the electric case the specific conductivity of the medium.

Now, I happened to notice, as a matter that greatly simplifies the calculation, that if we confine our attention to a transverse layer of the medium of given thickness, the resistance between the two bits of the cylinders in that layer depends on the ratio of the shortest distance separating them to their periphery, and is independent of the absolute size of the system. If you have the two cylinders an inch round, and an inch between them, then the resistance of the slab of medium (of given thickness) in which they lie will be the same as if they were a foot round and a foot apart. Now that simplifies matters very much, and thanks to my friend and former chief assistant, Dr. R. Mullineux Walmsley, who devoted himself to this troublesome calculation, I am able to give you, in tabular form, the magnetic resistances within the limits of proportion that are likely to occur.

The numbers from columns 1 and 2 of the following Table are plotted out graphically in

TABLE VIII.—MAGNETIC RELUCTANCE OF AIR BETWEEN TWO PARALLEL CYLINDRICAL LIMBS OF IRON.

$\frac{b}{p}$ Ratio of least distance apart to perimeter.	Magnetic reluctance in C.G.S. units = the magneto-motive force ÷ total magnetic flux.		Magnetic reluctance in inch units = the ampere-turns ÷ the total magnetic flux. Slab = 1 inch thick.	
	Reluctance.	Permeance.	Reluctance.	Permeance.
0·1	0·2461	4·063	0·0771	12·968
0·2	0·3404	2 938	0·1066	9·377
0·3	0·4084	2·449	0·1280	7·815
0 4	0·4628	2·161	0·1450	6·897
0 5	0·5084	1·967	0·1503	6·278
0·6	0·5479	1·825	0·1717	5·825
0·8	0·6140	1·629	0·1924	5·198
1·0	0·6681	1·497	0 2093	4·777
1·2	0·7144	1·400	0·2238	4·571
1·4	0·7550	1·324	0·2365	4·228
1·6	0·7903	1·265	0·2476	4·039
1·8	0·8220	1·217	0·2575	3·883
2·0	0·8511	1·202	6·2667	3·750
4·0	1·0500	0·952	0·3290	3·040
6·0	1·1710	0 854	0·3669	2·726
8·0	1·2624	0·792	0·3955	2·528
10·0	1·3250	0·755	6·4151	2·409

NOTE.—In the above Table, unit-length of cylinders is assumed (1 centimetre in columns 2 and 3; 1 inch in columns 4 and 5); the flow of magnetic lines being reckoned as in a slab of infinite extent, and of unit thickness. Symbols: p = perimeter of cylinder; b = shortest distance between cylinders. In columns 2 and 3 the unit reluctance is that of a centimetre cube of air. In columns 4 and 5 the unit reluctance is so chosen (as in the rest of these lectures wherever such measures are used) that the reduction of ampere-turns to magneto-motive force by multiplying by $4\pi \div 10$ is avoided. This will make the reluctance of the inch cube of air equal to $10 \div 4\pi \div 2{\cdot}54 = 0\ 3132$; and its permeance as 3·1931.

FIG. 46.

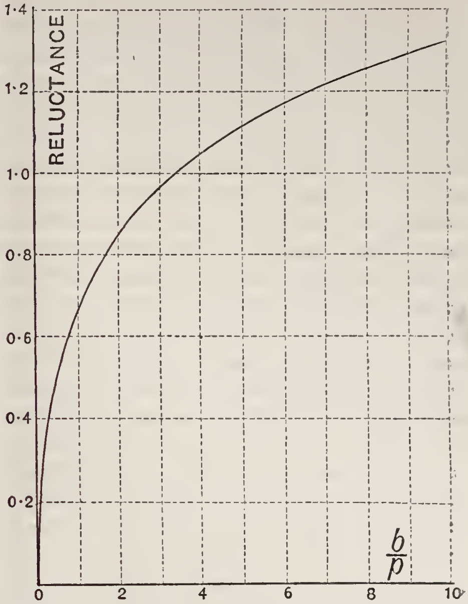


DIAGRAM OF LEAKAGE RELUCTANCES.

Fig. 46 for more convenient reference, As an example of the use of the Table we will take the following:—

EXAMPLE.—Find the magnetic reluctance and permeance between two parallel iron cores of 1 inch diameter and 9 inches long, the least distance between them between them being $2\frac{3}{8}$ inches. Here $b = 2{\cdot}375$; $p = 3{\cdot}1416$ $b \div p = 0{\cdot}756$. Reference to the Table shows (by interpolation) that the reluctance and permeance for unit thickness of slab are respectively 0·183 and 5·336. For 9 inches thickness they will therefore be 0·021 and 48·02 respectively.

When the permeance across between the two limbs is thus approximately calculable, the waste flux across the space is estimated by multiplying the permeance so found by the *average* value of the difference of magnetic potential between the two limbs. And this, if the yoke which unites the limbs at their lower end is of good solid iron, and if the parallel cores offer little magnetic reluctance as compared with the reluctance of the useful paths, or of that of the stray field, may be simply taken as half the ampere-turns (or, if centimetre measures are used, multiply by 1·2566).

The method here employed in estimating the reluctance of the waste field is of course only an approximation; for it assumes that the leakage takes place only in the planes of the slabs considered. As a matter of fact, there is always some leakage out of the planes of the slabs. The real reluctance is always therefore somewhat less, and the real permeance somewhat greater, than that calculated from Table VIII.

For the electromagnets used in ordinary telegraph instruments the ratio of b to p is not usually very different from unity, so that for them the permeance across from limb to limb per inch length of core is not very far from 5·0, or nearly twice the permeance of an inch cube of air.

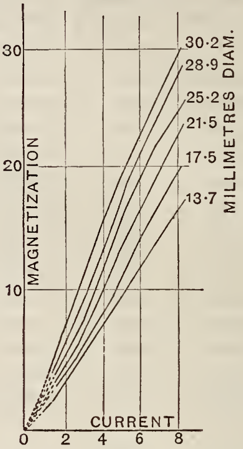
We are now in a position to see the reason for a curious statement of Count Du Moncel which for long puzzled me. He states that he found, using distance apart of one millimetre, that the attraction of a two-pole electromagnet for its armature was less when the armature was presented laterally than when it was placed in front of the pole-ends, in the ratio of 19 to 31. He does not specify in the passage referred to what was the shape of either the armature or the cores. If we assume that he was referring to an electromagnet with cores of the usual sort—round iron with flat ends, presumably like Fig. 11—then it is evident that the air gaps, when the armature is presented sideways to the magnet, are really greater than when the armature is presented in the usual way, owing to the cylindric curvature of the core. So, if at equal measured distance the reluctance in the circuit is greater, the magnetic flux will be less and the pull less.

It ought also now to be evident why an armature made of iron of a flat rectangular section, though when in contact it sticks on tighter edgeways, is at a distance attracted more powerfully if presented flatways. The gaps, when it is presented flatways (at an equal least distance apart) offer a lesser magnetic reluctance.

Another obscure point also becomes explainable, namely, the observations by Lenz, Barlow, and others, that the greatest amount of magnetism which could be imparted to long iron bars by a given circulation of electric current was (nearly) proportional, not to the cross-sectional area of the iron, but to its surface! The explanation is this. Their magnetic circuit was a bad one, consisting of a straight rod of iron and of a return path through air. Their magnetizing force was being in reality expended not so much on driving magnetic lines through iron (which is readily permeable) but on driving the magnetic lines through air (which is, as we know, much less permeable). and the reluctance of the return paths through the air is—when the distance from one to the other of the exposed end parts of the bar is great compared with its periphery—very nearly proportional to that periphery, that is to say, to the exposed surface.

Another opinion on the same topic was that of Professor Müller, who laid down the law that for iron bars of equal length, and excited by same magnetizing power, the amount of magnetism was proportional to the square root of the periphery. A vast amount of industrious scientific effort has been expended by Dub, Hankel, Von Feilitzsch, and others on the attempt to verify this "law." Not one of these experimenters seems to have had the faintest suspicion that the real thing which determined the amount of magnetic flow was not the iron but the reluctance of the return-path through air. Von Feilitzsch plotted out the accompanying curves (Fig. 47), from which he drew the inference that the law of the square root of the periphery was established. The very straightness of these curves shows that in no case had the iron become so much magnetized as to show the bend that indicates approaching saturation. Air, not iron, was offering the main part of the resistance to magnetization in the whole of these experiments. I draw from the very same curves the conclusion that the magnetization is not proportional to the square root of the periphery, but is more nearly proportional to the periphery itself; indeed, the angles at which the different curves belonging to the different peripheries rise show that the amount of magnetism is very nearly as the surface. Observe here we are not dealing with a closed magnetic circuit where section comes into account; we are dealing with a bar in which the magnetism can only get from one end to the other by leaking all round into the air. If, therefore, the reluctance of the air path from one end of the bar to the other is proportional to the surface, we should get some curves very like these; and that is exactly what happens. If you have a solid, of a certain given geometrical form, standing out in the middle of space, the conductance which the space around it (or rather the medium filling that space) offers to the magnetic lines flowing through it, is practically proportional to the surface. It is distinctly so for similar

FIG. 47.



VON FEILITZSCH'S CURVES OF MAGNETIZATION OF RODS OF VARIOUS DIAMETERS.

geometrical solids, when they are relatively small as compared with the distance between them. Electricians know that the resistance of the liquid between two small spheres, or two small disks of copper immersed in a large bath of sulphate of copper, is practically independent of the distance between them, provided they are not within ten diameters, or so, of one another. In the case of a long bar we may treat the distance between the protruding ends as sufficiently great to make an approximation to this law hold good. Von Feilitzsch's bars were, however, not so long that the average value of the length of path from one end surface to the other end surface, along the magnetic lines, was infinitely great as compared with the periphery. Hence the departure from exact proportionality to the surface. His bars were 9·1 centimetres long, and the peripheries of the six were respectively 94·9, 90·7, 79·2, 67·6, 54·9, and 42·9 millimetres.

It has long been a favourite idea with telegraph engineers that a long-legged electromagnet in some way possessed a greater "projective" power than a short-legged one; that, in brief, a long-legged magnet could attract an armature at a greater distance from its poles than could a short-legged one made with iron cores of the same section. The reason is not far to seek. To project or drive the magnetic lines across a wide intervening air-gap requires a large magnetizing force on account of the great reluctance, and the great leakage in such cases. And the great magnetizing force cannot be got with short cores, because there is not, with short cores, a sufficient length of iron to receive all the turns of wire that are in such a case essential. The long leg is wanted simply to carry the wire necessary to provide the requisite circulation of current.

We now see how, in designing electromagnets, the length of the iron core is really determined; it must be long enough to allow of the winding upon it of the wire which, without overheating, will carry the ampere-turns of exciting current which will suffice to force the requisite number of magnetic lines (allowing for leakage) across the reluctances in the useful path. We shall come back to this matter after we have settled the mode of calculating the quantity of wire that is required.

Being now in a position to calculate the additional magnetizing power required for forcing magnetic lines across an air gap, we are prepared to discuss a matter that has been so far neglected, namely, the effect on the reluctance of the magnetic circuit, of joints in the iron. Horse-shoe electromagnets are not always made of one piece of iron bent round. They are often made, like Fig. 11, (p. 878) of two straight cores shouldered and screwed, or rivetted into a yoke. It is a matter purely for experiment to determine how far a transverse plane of section across the iron obstructs the flow of magnetic lines. Armatures, when in contact with the cores, are never in perfect contact, otherwise they would cohere without the application of any magnetizing force; they are only in imperfect contact, and the joint offers a considerable magnetic reluctance. This matter has been examined by Professor J. J. Thomson and Mr. Newall, in the Cambridge Philosophical Society's Proceedings, in 1887; and recently more fully by Professor Ewing, whose researches are published in the "Philosophical Magazine" for September, 1888. Ewing not only tried the effect of cutting and of facing up with true plane surfaces, but used different magnetizing forces, and also applied various external pressures to the joint. For our present purpose we need not enter into the questions of external pressures, but will summarise the results which Ewing found when his bar of wrought iron was cut across by section planes, first into two pieces, then into four, then into eight. The apparent permeability of the bar was reduced at every cut.

TABLE IX.—Effect of Joints in Wrought Iron Bar (not compressed).

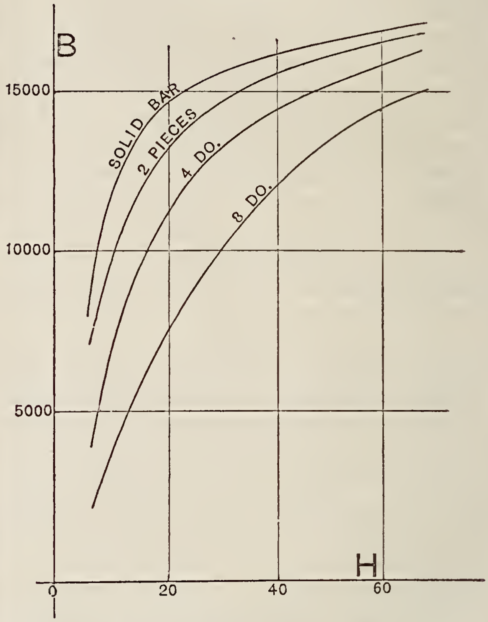
H	B				Mean thickness of equivalent air-space for one cut.		Thickness of iron of equivalent reluctance per cut.	
	Solid.	Cut in Two.	In Four.	In Eight.	Centimetres.	Inches.	Centimetres.	Inches.
7·5	8,500	6,900	4,809	2,600	0·0036	0·0014	4	1·57
15	13,400	11,550	8,900	5,550	0·0030	0·0012	2·53	1·00
30	15,350	14,550	12,940	9,800	0·0020	0·0008	1·10	0·433
50	16,400	15,950	1,5000	13,300	0·0013	0·0005	0·43	0·169
70	17,100	16,840	16,120	15,200	0·0009	0·0004	0·22	0·087

Suppose we are working with the magnetization of our iron pushed to about 16,000 lines to the square centimetre (*i.e.*, about 150 lbs. per square inch, traction), requiring a magnetizing force of about $H = 50$; then, referring to the Table, we see that each joint across the iron offers as much reluctance as would an air-gap 0·0005 of an inch in thickness, or adds as much reluctance as if an additional layer of iron about 1·6th of an inch thick had been added. With small magnetizing forces the effect of having a cut across the iron with a good surface on it is about the same as though you had introduced a layer of air $\frac{1}{600}$th of an inch thick, or as though you had added to the iron circuit about 1 inch of extra length. With large magnetizing forces, however, this disappears, probably because of the attraction of the two surfaces across that cut. The stress in the magnetic circuit, with high magnetic forces running up to 15,000 or 20,000 lines to the square centimetre, will of itself put on a pressure of 130 to 230 lbs. to the square inch, and so these resistances are considerably reduced; they come down in fact to about 1-20th of their initial value. When Ewing specially applied compressing forces, which were as large as 670 lbs. to the square inch, which would of themselves ordinarily, in a continuous piece of iron, have diminished the magnetizability, he found the diminution of the magnetizability of iron itself was nearly compensated for by the better conduction of the cut surface. The old surface, cut and compressed in that way, closes as it were magnetically up—does not act like a cut at all; but at the same time you lose just as much as you gain, because the iron itself becomes less magnetizable.

The above results of Ewing's are further represented by the curves of magnetization drawn in Fig. 48. When the faces of a cut were carefully surfaced up to true planes, the disadvantageous effect of the cut was reduced considerably, and, under the application of a heavy external pressure, almost vanished.

I have several times referred to experimental results obtained in past years, principally by German and French workers, buried in obscurity in the pages of foreign scientific journals, Too often, indeed, the scattered papers of the German physicists are rendered worthless or unintelligible by reason of the omission of some of the data of the experiments. They give no measurements perhaps of their currents, or they used an uncalibrated galvanometer, or they do not say how many windings they were using in their coils; or perhaps they give their results in some obsolete phraseology. They are extremely addicted to informing you about the "magnetic moments" of their magnets. Now the magnetic moment of an electromagnet is the one thing that one never wants to know. Indeed the magnetic moment of a magnet of any kind is a useless piece of information, except in the case of bar-magnets of hard steel that are to be used in the determination of the horizontal component of the earth's magnetic force. What one does want to know about an electromagnet is the number of magnetic lines flowing through its circuit, and this the older researches rarely afford the means of ascertaining. Nevertheless, there are some investigations worthy of study to which time will now only permit me very briefly to allude. These are the researches of Dub on the effect of thickness of armatures, and those of Nicklès and of Du Moncel on the lengths of armatures. Also those of Nicklès on the effect of width between the two limbs of the horse-shoe electromagnet.

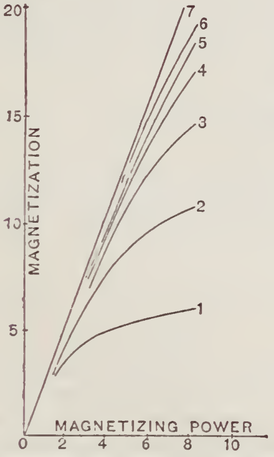
FIG. 48.



EWING'S CURVES FOR EFFECT OF JOINTS.

I can only now describe some experiments of Von Feilitzsch upon the vexed question of tubular cores, a matter touched by Sturgeon, Pfaff, Joule, Nicklès, and later by Du Moncel. To examine the question whether the inner part of the iron really helps to carry the magnetism, Von Feilitzsch prepared a set of thin iron tubes which could slide inside one another. They were all 11 centimetres long, and their peripheries varied from 6·12 centimetres to 9.7 centimetres. They could be pushed within a magnetizing spiral to which either small or large currents could be applied, and their effect in deflecting a magnetic needle was noted, and balanced by means of a compensating steel magnet, from the position of which the forces were reckoned and the magnetic moments calculated out. As the tubes were of equal lengths, the magnetization is approximately proportional to the magnetic moment. The outermost tube was first placed in the spiral, and a set of observations made; then the tube of next smaller size was slipped into it and another set of observations made; then a third tube was slipped in until the whole of the seven were in use. Owing to the presence of the outer tube in all the experiments, the reluctance of the air return paths was alike in every case. The curves given in Fig. 49 indicate the results.

FIG. 49.



VON FEILITZSCH'S CURVES OF MAGNETIZATION OF TUBES.

The lowest curve is that corresponding to the use of the first tube alone. Its form, bending over and becoming nearly horizontal, indicates that with large magnetizing power it became nearly saturated. The second curve corresponds to the use of the first tube with the second within it. With greater section of iron saturation sets in at a later stage. Each successive tube adds to the capacity for carrying magnetic lines, the beginning of saturation being scarcely perceptible, even with the highest magnetizing power, when all seven tubes were used. All the curves have the same initial slope. This indicates that with small magnetizing forces, and when even the least quantity of iron was present, when the iron was far from saturation, the main resistance to magnetization was that of the air paths, and it was the same whether the total section of iron in use was large or small.

I must leave till my next lecture the rules relating to the determination of the windings of copper wire on the cores.

APPENDIX TO LECTURE II.

CALCULATION OF EXCITATION, LEAKAGE, &C.

Symbols used.

N = whole number of magnetic lines (C.G.S., definition of magnetic lines, being 1 line per sq. centim. to represent intensity of a magnetic field, such that there is 1 dyne on unit magnetic pole) that pass through the magnetic circuit. Also called the *magnetic flux*.

B = the number of magnetic lines per square centimetre, in the iron; also called the *induction*, or the internal magnetization.

$\mathbf{B}_{\prime\prime}$ = the number of magnetic lines per square inch in the iron.

H = the magnetic force or intensity of the magnetic field, in terms of the number of magnetic lines to the square centimetre that there would be in air.

$\mathbf{H}_{\prime\prime}$ = the magnetic force, in terms of the number of magnetic lines that there would be to the square inch, in air.

μ = the *permeability* of the iron, &c.; that is its magnetic conductivity or multiplying power for magnetic lines.

A = area of cross section, in square centimetres.

A″ = area of cross section, in square inches.

l = length, in centimetres.

l'' = length, in inches.

S = number of spirals or turns in the magnetizing coil.

i = electric current, expressed in amperes.

v = coefficient of allowance for leakage; being the ratio of the whole magnetic flux to that part of it which is usefully applied. (It is always greater than unity.)

Relations of Units.

1 inch = 2·54 centimetres;
1 centimetre = 0·3937 inch.

1 square inch = 6·45 square centimetres;
1 square centimetre = 0·1550 square inch.

1 cubic inch = 16·39 cubic centimetres;
1 cubic centimetre = 0·0610 cubic inch.

To calculate the value of $\mathbf{B}$ or of $\mathbf{B}_{''}$ from the Traction.

If P denote the pull, and A the area over which it is exerted, the following formulæ (derived from Maxwell's law, see p. 899) may be used :—

$$\mathbf{B} = 4{,}965 \sqrt{\frac{\text{P kilos.}}{\text{A sq. cm.}}} ;$$

$$\mathbf{B} = 1{,}316{\cdot}6 \sqrt{\frac{\text{P lbs.}}{\text{A sq. in.}}} ; \text{ or}$$

$$\mathbf{B}_{''} = 8{,}494 \sqrt{\frac{\text{P lbs.}}{\text{A sq. in.}}} .$$

To calculate the requisite cross-section of Iron for a given Traction.

Reference to p. 896 will show that it is not expedient to attempt to employ tractive forces exceeding 150 lbs. per square inch in magnets whose cores are of soft wrought iron, or exceeding 28 lbs. per square inch in cast iron. Dividing the given load that is to be sustained by the electromagnet by one or other of these numbers, gives the corresponding requisite sectional area of wrought or cast iron respectively.

To calculate the Permeability from $\mathbf{B}$ or from $\mathbf{B}_{''}$.

This can only be satisfactorily done by referring to a numerical Table (such as Table II. or IV.), or to graphic curves, such as Fig. 18, in which are set down the result of measurements made on actual samples of iron of the quality that is to be used. The values of μ for the two specimens of iron to which Table II. refers may be *approximately* calculated as follows :—

$$\text{For annealed wrought iron, } \mu = \frac{17{,}000 - \mathbf{B}}{3{\cdot}5} ;$$

$$\text{For grey cast iron, } \mu = \frac{7{,}000 - \mathbf{B}}{3{\cdot}2} .$$

These formulæ must not be used for the wrought iron for tractions that are less than 28 lbs. per square inch, nor for cast iron for tractions less than 2¼ lbs. per square inch.

To calculate the Total Magnetic Flux which a core of given sectional area can conveniently carry.

It has been shown that it is not expedient to push the magnetization of wrought iron beyond 100,000 lines to the square inch, nor that of cast iron beyond 42,000. These are the highest values that ought to be assumed in designing electromagnets. The total magnetic flux is calculated by multiplying the figure thus assumed by the number of square inches of sectional area.

To calculate the Magnetizing Power requisite to force a given number of Magnetic Lines through a definite Magnetic Reluctance.

Multiply the number which represents the magnetic reluctance by the total number of magnetic lines that are to be forced through it. The product will be the amount of magneto-motive force. If the magnetic reluctance has been expressed on the basis of centimetre measurements, the magneto-motive force, calculated as above, will need to be divided by $1{\cdot}2566 \left(\textit{i.e.}, \text{ by } \frac{4\pi}{10} \right)$ to give the number of ampere-turns of requisite magnetizing power. If, however, the magnetic reluctance has been expressed in the units explained below, based upon inch measures, the magnetizing power, calculated by the rule given above, will already be expressed directly in ampere-turns.

TO CALCULATE THE MAGNETIC RELUCTANCE OF AN IRON CORE.

(*a.*) *If dimensions are given in centimetres.*—Magnetic reluctance being directly proportional to length, and inversely proportional to sectional area and to permeability, the following is the formula :—

$$\text{Magnetic reluctance} = \frac{l}{A\mu} ;$$

but the value of μ cannot be inserted until one knows how great $\mathbf{B}$ is going to be; when reference to Table II. gives μ.

(*b.*) *If dimensions are given in inches.*—In this case we can apply a numerical co-efficient, which takes into account the change of units (2·54), and also, at the same time, includes the operation of dividing the magneto-motive force by $\frac{4}{10}$ of π ($= 1{\cdot}2566$) to reduce it to ampere-turns. So the rule becomes

$$\text{Magnetic reluctance} = \frac{l''}{A''\mu} \times 0{\cdot}3132.$$

Example.—Find the magnetic reluctance from end to end of a bar of wrought-iron 10 inches long, with a cross-section of 4 square inches, on the supposition that the magnetic flux through it will amonnt to 440,000.

To calculate the Total Magnetic Reluctance of a Magnetic Circuit.

This is done by calculating the magnetic reluctances of the separate parts, and adding them together. Account must, however, be taken of leakage; for when the flux divides, part going through an armature, part through a leakage path, the law of shunts comes in, and the nett reluctance of the joint paths is the reciprocal of the sum of their reciprocals. In the simplest case the magnetic circuit consists of 3 parts (1) armature, (2) air in the 2 gaps, (3) core of the magnet. These three reluctances may be separately written, as in the Table in next column.

If the iron used in armature and core is of the same quality, and magnetised up to the same degree of saturation, μ_1 and μ_3 will be alike. For the air-gaps $\mu = 1$, and therefore is not written in.

If there were no leakage, the total reluctance would simply be the sum of these three terms. But when there is leakage, the total relnctance is reduced.

	For Centimetre Measure.	For Inch Measure.
1. Armature	$\frac{l_1}{A_1\mu_1}$	$\frac{l''_1}{A''_1\mu_1} \times 0{\cdot}3132$
2. The Gaps	$2\frac{l_2}{A_2}$	$2\frac{l''_2}{A''_2} \times 0{\cdot}3132$
3. Magnet Core..	$\frac{l_3}{A_3\mu_3}$	$\frac{l''_3}{A''_3\mu_3} \times 0{\cdot}3132$

To calculate the ampere-turns of Magnetizing Power requisite to force the desired Magnetic Flux through the reluctances of the Magnetic Circuit.

(a.) If dimensions are given in centimetres the rule is :—

Ampere-turns = the magnetic flux, multiplied by the magnetic reluctance of the circuit, divided by $\frac{4}{10}$ of π (= 1·2566).

Or, in detail, the three separate amounts of ampere-turns required for three principal magnetic reluctances are explained as follows :—

$$\left.\begin{array}{l}\text{Ampere-turns required to drive } \mathbf{N} \text{ lines}\\ \text{through iron of armature ....}\end{array}\right\} = \mathbf{N} \times \frac{l_1}{A_1\,\mu_1} \div \frac{4\pi}{10},$$

$$\left.\begin{array}{l}\text{Ampere-turns required to drive } \mathbf{N} \text{ lines}\\ \text{through the two gaps ....}\end{array}\right\} = \mathbf{N} \times \frac{2l_2}{A_2} \div \frac{4\pi}{10},$$

$$\left.\begin{array}{l}\text{Ampere-turns required to drive } v\mathbf{N}\\ \text{lines through the iron of magnet core}\end{array}\right\} = v\mathbf{N} \times \frac{l_3}{A_3\mu_3} \div \frac{4\pi}{10},$$

And, adding up :—

$$\text{Total ampere-turns required} = \frac{10}{4\pi}\mathbf{N}\left\{\frac{l_1}{A_1\,\mu_1} + \frac{2l_2}{A_2} + \frac{vl_3}{A_3\,\mu_3}\right\}.$$

(*b.*) *If dimensions are given in inches*, the rule is :—Ampere-turns = magnetic flux multiplied by the magnetic reluctance of the circuit. Or, in detail :—

$$\left.\begin{array}{l}\text{Ampere-turns required to drive } \mathbf{N} \text{ lines}\\ \text{through iron of armature ....}\end{array}\right\} = \mathbf{N} \times \frac{l''_1}{A''_1\mu_1} \times 0{\cdot}3132,$$

$$\left.\begin{array}{l}\text{Ampere-turns required to drive } \mathbf{N} \text{ lines}\\ \text{through two gaps ....}\end{array}\right\} = \mathbf{N} \times \frac{2l''_2}{A''_2} \times 0{\cdot}3132,$$

$$\left.\begin{array}{l}\text{Ampere-turns required to drive } v\mathbf{N} \text{ lines}\\ \text{through iron core of magnet........}\end{array}\right\} = v\mathbf{N} \times \frac{l''_3}{A''_3\,\mu_3} \times 0{\cdot}3132;$$

And, adding up :—

$$\text{Total ampere-turns required} = 0{\cdot}3132\,\mathbf{N}\left\{\frac{l''_1}{A''_1\,\mu_1} + \frac{2\,l''_2}{A''_2} + \frac{vl''_3}{A''_3\,\mu_3}\right\}.$$

It will be noted that here v, the coefficient of allowance for leakage, has been introduced. This has to be calculated as shown later. In the meantime it may be pointed out that, in designing electromagnets for any case where v is approximately known beforehand, the calculation may be simplified by taking the sectional area of the magnet core greater than that of the armature in the same proportion. For example, if it were known that the waste lines that leak were going to be equal in number to those that are usefully employed in the armature (here $v = 2$), the iron of the cross might be made of double the section of that of the armature. In this case μ_3 will approximately equal u_1.

To calculate the Coefficient of Allowance for Leakage, v.

v = total magnetic flux generated in magnet core ÷ useful magnetic flux through armature. The respective useful and waste magnetic fluxes are proportional to the permeances along their respective paths. *Permeance*, or magnetic conductance, is the reciprocal of the *reluctance*, or magnetic resistance. Call useful permeance through armature and gaps u; and the waste permeance in the stray field w; then

$$v = \frac{u + w}{u}$$

w may be estimated by the Table VIII. given on

p. 919, or other leakage rules, but should be divided by 2 as the average difference of magnetic potential over the leakage surface is only about half that at the ends of the poles.

RULES FOR ESTIMATING MAGNETIC LEAKAGE.

(I to III Adapted from Prof. Forbes' rules.)

Prop. I. Permeance between two parallel areas facing one another.—Let areas be A_1'' and A_2'' square inches, and distance apart d'' inches, then :—

$$\text{Permeance} = 3{\cdot}193 \times \tfrac{1}{2}\left(A''_1 + A''_2\right) \div d''.$$

Prop. II. Permeance between two equal adjacent rectangular areas lying in one plane.—Assuming lines of flow to be semicircles, and that distances d''_1 and d''_2 between their nearest and furthest edges respectively are given, also a'' their width along the parallel edge :—

$$\text{Permeance} = 2{\cdot}274 \times a'' \times \log_{10} \frac{d_2''}{d_1''}.$$

Prop. III. Permeance between two equal parallel rectangular areas lying in one plane at some distance apart.—Assume lines of leakage to be quadrants joined by straight lines.

$$\text{Permeance} = 2{\cdot}274 \times a'' \times \log_{10} \left\{ 1 + \frac{\pi(d''_2 - d_1'')}{d''_1} \right\}$$

Prop. IV. Permeance between two equal areas at right angles to one another.

Permeance (if air angle is 90°) = double the respective value calculated by II. or III.

Permeance (if air angle is 270°) = 1½ times the respective value calculated by II.

If measures are given in centimetres these rules become the following :—

I. $\tfrac{1}{2}\left(A_1 + A_2\right) \div d;$

II. $\dfrac{a}{\pi} \log_e \dfrac{d_2}{d_1};$

III. $\dfrac{a}{\pi} \log_e \left(1 \times \dfrac{\pi(d_2 - d_1)}{d_1} \right).$

Prop. V. Permeance between two parallel cylinders of indefinite length.

The formula for the reluctance is given on p. 925 above: the permeance is the reciprocal of it. Calculations are simplified by reference to Table VIII.

Miscellaneous.

THE LINEFF ELECTRIC TRAMWAY.*

The conductor consists of bare copper strip or cable and of iron strip. The latter is galvanised so as to protect it from rusting. It lies on the copper conductor, and both are enclosed in a sealed channel formed of asphalte. The copper conductor rests upon the bottom of a trough made of a succession of glazed tiles, and the cover to this trough is formed by the lower flanges of iron rails arranged in short sections so as to be insulated from each other. The head of one rail reaches up to the surface of the road, the head of the other is cut off, and this rail is therefore completely buried in the asphalte. The surface rail, which may be arranged alongside one of the ordinary tram rails or in the centre of the track, is in electric and magnetic contact with an electromagnet carried under the car. This magnet runs upon the surface rail on wheels which form its north and south poles. The distance of the wheels is greater than the length of a section of insulated rail, so that successive sections become oppositely magnetised. This causes the iron strip immediately below the magnetised region to be attracted upwards, and thus come into contact for a length of several feet with the under side of the two sectional rails. At the same time the iron strip to both sides of this region remains in contact with the copper conductor, and forms thus an electrical connecting link between the copper conductor and a few sections of insulated rail under the car. The current passes from the surface rail through the body of the electromagnet (which is insulated from the body of the car) into the motor, and finally into the ordinary tram rails and earth in the usual manner. The electromagnet is energised by a shunt current obtained from the main conductor, but to provide for the possibility of dropping the strip from some unforeseen cause, there is placed on the electromagnet a third thick wire coil, which can at all times be energised by two storage cells carried on the car, and thus the strip can be picked up and the main circuit again established if it should have been accidentally interrupted. I may, however, at once state that during some tests which I made on an experimental line of this kind, and which lasted over several days, there has been no need for the picking-up battery, as the current was never lost. The way in which Mr. Lineff makes use of magnetic lines of force to effect the attraction of the iron strip deserves attention. It might, perhaps, be thought that the most direct, and therefore the best, way of utilising the lines of force would be by one single line of sectional rail, through which there would be longitudinal magnetic flux, corresponding with the fore and aft position of the poles, and attraction of the strip at every gap between two sections. Experiment has, however, shown that this apparently direct way is by no means the best way, and that far more satisfactory results can be obtained by arranging a more roundabout course for the lines of force. This is attained by the employment of the subsidiary or buried rail, the gaps in which do not exactly correspond with those in the main or surface rail, but are shifted forward by a certain amount. In consequence of this arrangement, the buried rail acts as a kind of magnetic bridge to successive portions of the surface rail, and this action takes place in two ways, one direct, and the other indirect. The direct way is longitudinal, and does not affect the strip at all. The indirect way is both longitudinal and transverse, the latter passing several times through the strip. The buried rail is a rather imperfect bridge to the lines of force traversing it longitudinally, because its magnetic resistance in that direction is very great, but this rail forms a very efficient bridge for lines passing through it transversely, owing to its lower magnetic resistance in that direction which includes the strip. The flow of magnetic force transversely is, therefore, that which effects the attraction of the strip, and may be represented as a series of magnetic stitches passing to and fro between the two sets of rails and the strip.

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* Abstract of paper read by Gisbert Kapp before Section G (Mechanical Science) of the British Association, Leeds, 1890.

CHICAGO EXHIBITION, 1893.

The following letter appeared in a recent issue of the *Times*:—

Sir,—So little appears to be known in England about the arrangements for the proposed American Exhibition of 1893 that it may interest a good many of your readers to hear what is really doing in Chicago, and how far any actual progress has been made.

I have just received from Chicago what purports to be the latest news on the subject, and some documents showing what action has been taken up to date. Possibly a summary of these may be worth publication in the *Times*.

The "World's Exposition of 1892," as a matter of fact, is not to be opened till May, 1893, but since 1492 was the date of Columbus's great discovery, and since nothing worthy of commemoration appears to have happened in 1493, it was considered desirable to keep up the association with the former year by a provision in the Act of Congress appointing the Exhibition Commission, that the buildings in Chicago are to be dedicated on October 12, 1892.

Since the Exhibition, though under the patronage and authority of the United States Government, is not actually a Government undertaking, it may be worth while to explain what its organisation really is. It is under the dual control of a Commission appointed by Act of Congress, and a Corporation established under the laws of the State of Illinois (in which Chicago is situated). The Corporation has to provide a site and plans for the buildings, and to show funds available to the extent of $10,000,000, or £2,000,000. When the Commission are satisfied that the funds will be forthcoming, they are empowered to accept a site, and to take all necessary steps for the organisation, though certain of the financial arrangements appear to be left to the Corporation, under the control of the Commission. The Commission includes representatives from all the States, and is composed of 113 members in all. The Corporation consists of 45 prominent citizens of Chicago.

So soon as the President of the United States shall be informed by the Commission that the necessary conditions have been fulfilled, it will be his duty to issue a proclamation announcing the Exhibition, and to invite foreign countries to take part in it. This invitation will, of course, be sent through the usual diplomatic channels.

The Act of Congress provides a sum of $1,500,000 for the erection of special buildings for the Government exhibits, and empowers the various State Departments to contribute. It also nominates a special Board for the supervision of this portion of the Exhibition. An immediate grant of $20,000 (£4,000) is made "for purposes connected with the admission of foreign goods." Beyond these grants the State is to have no pecuniary liability whatever.

It is a little surprising to learn that the final decision as to the site has not yet—or had not a fortnight ago—been decided, but I understand that this essential question will be immediately settled, and news of the decision may be looked for daily. As regards funds, more than half the two millions has been subscribed, and I am informed that it is probable that a grant of a million will be made by the city of Chicago with the condition that it is to be refunded from the receipts.

It is proposed to have half as much space again as at Paris under cover, and ground of twice the area. Having regard to the fact that the total expenditure at Paris was about £1,600,000, and that at least a million may be expected from admissions and other sources of revenue, it will be seen that the guarantee fund proposed should be ample, even if an expenditure much heavier than at Paris be incurred.

Goods for exhibition will be admitted duty free, but Customs dues will be levied on any of such goods sold in the United States.

How far the proposals of the promoters of the Chicago Exhibition will be carried into effect remains to be seen. They have sufficient, even ample, time before them, but they have no time to waste. If the Exhibition is to be a success we ought to hear very soon that the site has been fixed upon, the guarantee fund subscribed, and the Federal Commission at work.

I am, Sir, your obedient servant,
H. TRUEMAN WOOD.
Society of Arts, Adelphi, W.C.

THE ROYAL SOCIETY OF NEW SOUTH WALES.

The Royal Society of New South Wales offers its medal and money prize for the best communication (provided it be of sufficient merit) containing the results of original research or observation upon each of the following subjects :—Series X.—To be sent in not later than 1st May, 1891. No. 34.—The Meteorology of Australia, New Zealand, and Tasmania. The Society's Medal and £25. No. 35.—

Anatomy and Life History of the Echidna and Platypus. The Society's Medal and £25. No. 36.—The Microscopic Structure of Australian Rocks. The Society's Medal and £25. Series XI.—To be sent in not later than 1st May, 1892. No. 37.—On the Iron Ore Deposits of New South Wales. The Society's Medal and £25. No. 38.—On the effect which settlement in Australia has produced upon Indigenous Vegetation, especially the depasturing of sheep and cattle. The Society's Medal and £25. No. 39.—On the Coals and Coal Measures of Australasia. The Society's Medal and £25.

The competition is in no way confined to members of the Society, nor to residents in Australia, but is open to all without any restriction whatever, excepting that a prize will not be awarded to a Member of the Council for the time being; neither will an award be made for a mere compilation, however meritorious in its way. The communication to be successful must be either wholly or in part the result of original observation or research on the part of the contributor.

The successful papers will be published in the Society's annual volume. Fifty reprint copies will be furnished to the author free of expense.

Competitors are requested to write upon foolscap paper—on one side only. A motto must be used instead of the writer's name, and each paper must be accompanied by a sealed envelope bearing the motto outside, and containing the writer's name and address inside.

All communications to be addressed to the Honorary Secretaries, the Society's House, 3, Elizabeth-street, Sydney.

Notes on Books.

THE GOLDEN GATES OF TRADE. By John Yeats, LL.D. London: Philip. 1890.

This is intended as an introduction to the study of commercial geography, or rather, as the author professes to put it, to the science of commerce. It deals with such subjects as the sources of supply of our commercial staples, their distribution by means of the various trade-routes, the principles which govern modern commerce, and the changes which the changed condition of modern civilisation have introduced, emigration, exchange, the student's requirements for business and his training. Questions on the subject-matter of each chapter are added, and the author has also reprinted the papers of questions on commercial history and geography which he set as examiner in that subject for the Society of Arts from 1875 to 1881.

MAP STUDIES OF THE MERCANTILE WORLD. By John Yeats, LL.D. London: George Philip and Son. 1890.

This is another of Dr. Yeats' manuals of commercial instruction. The information it contains is arranged under the respective countries. Thus we have first the physical features of a country briefly described, then its natural resources, its principal industrial products, its commercial position generally, its chief ports, means of transit, lines of trade, trade movements, internal and external, &c. The survey extends over the whole world, the countries of Europe being dealt with in rather greater detail apparently than the rest.

GEOMETRICAL DRAWING FOR ART STUDENTS. By J. H. Morris. PRACTICAL, PLANE, AND SOLID GEOMETRY. By J. H. Morris. London: Longmans. 1890.

Except that each of these books has a different title-page and preface, they are, page for page, identical to the end of the first-named. "Practical, Plane, and Solid Geometry" contains an additional section on "Solid and Descriptive Geometry," including graphic arithmetic. They may, therefore, be noticed as a single work. The book is fully illustrated, the diagrams being conveniently placed on the opposite pages to the problems. It covers the Science and Art Department range, giving numerous problems of the usual character, instruction in the construction and use of scales, &c., and a chapter on the application of geometry to the preparation of patterns and designs for architectural tracery.

General Notes.

RAILWAYS IN CANADA.—The Canadian railway system has increased from 7,596 miles in 1881 to 13,324 on June 30th, 1889. Of this mileage, 9,505 are controlled under three managements—the Government, 1,363 miles; the Canadian Pacific, 4,973 miles; and the Grand Trunk, 3,179 miles; leaving 3,819 miles under other control. The earnings per mile are very low, $3,37; the only lines of large earnings being those between Buffalo and Detroit, which handled a heavy American traffic. Deducting these the average earnings of the Canadian system are some $2,650 per mile. The train-miles per mile of road have decreased from 3,760 in 1881, to 3,074 in 1889, because of the large mileage constructed in thinly-populated districts. The inhabitants per mile of road are 383, against about 400 in the United States.

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FRIDAY, OCTOBER 3, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

EXAMINATIONS, 1891.

The subjects of examination are—1. Arithmetic; 2. English (including composition and correspondence, and précis writing); 3. Book-keeping; 4. Commercial Geography; 5. Shorthand; 6. Type-writing; 7. French; 8. German; 9. Italian; 10. Spanish; 11. Portuguese; 12. Russian; 13. Danish; 14. Chinese; 15. Japanese; 16. Political Economy; 17. Domestic Economy; 18. Theory of Music; 19. Practice of Music.

These examinations will be held on March 16, 17, 18, and 19, with the exception of that in the Practice of Music, which will be held during the week commencing on the 1st of June.

In addition to the syllabus of examinations, the Programme contains an appendix giving the questions set in 1890, and the reports of the examiners on the papers worked.

The Programme is now ready. Copies can be obtained gratis on application to the Secretary.

Proceedings of the Society.

CANTOR LECTURES.

THE ELECTROMAGNET.

By Professor Silvanus P. Thompson, D.Sc., B.A., M.I.E.E.

Lecture III.—Delivered February 3, 1890.

Special Designs.

In continuation of my lecture of last week, I have to make a few remarks before entering upon the consideration of special forms of magnets, which was to form the entire topic of to-night's lecture. I had not quite finished the experimental results which related to the performance of magnets under various conditions. I had already pointed out that where you require a magnet simply for holding on to its armature, common sense (in the form of our simplest formula) dictated that the circuit of iron should be as short as was compatible with getting the required amount of winding upon it. That at once brings us to the question of the difference in performance of long magnets and short ones. Last week we treated that topic so far as this, that if you require your magnet to attract over any range across an air space, you required a sufficient amount of exciting power in the circulation of electric current to force the magnetic lines across that resistance, and therefore you required length of core in order to get the required coil wound upon the magnetic circuit. But there is one other way in which the difference of behaviour between long and short magnets—I am speaking of horse-shoe shapes—comes into play. So far back as 1840, Ritchie found that it was more difficult to magnetize steel magnets (using for that purpose electromagnets to stroke them with) if those electromagnets were short than if they were long. He was, of course, comparing magnets which had the same tractive power, that is to say, presumably had the same section of iron magnetized up to the same degree of magnetization. This difference between long and short cores is obviously to be explained on the same principle as the greater projecting power of the long-legged magnets. In order to force magnetism not only through an iron arch but through whatever is beyond, which has a lesser permeability for magnetism, whether it be an air gap or an arch of hard steel destined to retain some of its magnetism, you require magnetomotive force enough to drive the magnetism through that resisting medium; and, therefore, you must have turns of wire; that implies that you must have length of leg on which to wind those turns. Ritchie also found that the amount of magnetism remaining behind in the soft iron arch, after turning off the current, at the first removal of the armature, was a little greater with long than with short magnets; and, indeed, it is what we should expect now, knowing the properties of iron, that long pieces, however soft, retain a little more—have a little more memory, as it were, of having been magnetized—than short pieces. Later on I shall have specially to draw your attention to the behaviour of short pieces of iron which have no magnetic memory.

WINDING OF THE COPPER.

I now take up the question of winding the copper wire upon the electromagnet. How are we to determine beforehand the amount of wire required, and the proper gauge of wire to employ?

The first stage of such a determination is already accomplished; we are already in possession of the formulæ for reckoning out the number of ampere-turns of excitation required in any given case. It remains to show how from this to calculate the amount of bobbin-space, and the quantity of wire to fill it. Bear in mind that a current of ten amperes (*i.e.*, as strong as that used for a big arc light) flowing once around the iron, produces exactly the same effect magnetically as a current of one ampere flowing around ten times, or as a current of only one-hundredth part of an ampere flowing around a thousand times. In telegraphic work the currents ordinarily used in the lines are quite small, usually from five to twenty thousandths of an ampere; hence in such cases the wire that is wound on need only be a thin one, but it must have a great many turns. Because it is thin and has a great many turns, and is consequently a long wire, it will offer a considerable resistance. That is no advantage, but does not necessarily imply any greater waste of energy than if a thicker coil of fewer turns were used with a correspondingly larger current. Consider a very simple case. Suppose a bobbin is already filled with a certain number of turns of wire, say 100, of a size large enough to carry one ampere, without over-heating. It will offer a certain resistance, it will waste a certain amount of the energy of the current, and it will have a certain magnetizing power. Now suppose this bobbin to be re-wound with a wire of half the diameter; what will the result be? If the wire is half the diameter it will have one quarter the sectional area, and the bobbin will hold four times as many turns (assuming insulating materials to occupy the same percentage of the available volume). The current which such a wire will carry will be one-fourth as great. The coil will offer sixteen times as much resistance, being four times as long and of one-fourth the cross-section as the other wire. But the waste of energy will be the same, being proportional to the resistance and to the square of the current; for $16 \times \frac{1}{16} = 1$. Consequently the heating effect will be the same. Also the magnetizing power will be the same, for though the current is only one-quarter of an ampere, it flows around four hundred turns; the ampere-turns are one hundred, the same as before. The same argument would hold good with any other numerical instance that might be given. It therefore does not matter in the least to the magnetic behaviour of the electromagnet whether it is wound with thick wire or thin wire, provided the thickness of the wire corresponds to the current it has to carry, so that the same number of watts of power are spent in heating it. For a coil wound on a bobbin of given volume the magnetizing power is the same for the same heat waste. But the heat waste increases in a greater ratio than the magnetizing power, if the current in a given coil is increased; for the heat is proportional to the square of the current, and the magnetizing power is simply proportional to the current. Hence it is the heating effect which in reality determines the winding of the wire. We must—assuming that the current will have a certain strength—allow enough volume to admit of our getting the requisite number of ampere-turns without over-heating. A good way is to assume a current of one ampere while one calculates out the coil. Having done this, the same volume holds good for any other gauge of wire appropriate to any other current. The terms "long-coil" magnet and "short-coil" magnet are appropriate for those electromagnets which have, respectively, many turns of thin wire and few turns of thick wire. These terms are preferable to "high-resistance" and "low-resistance," sometimes used to designate the two classes of windings, because, as I have just shown, the resistance of a coil has in itself nothing to do with its magnetizing power. Given the volume occupied by the copper, then for any current-density (say, for example, a current-density of 2,000 amperes per square inch of cross-section of the copper), the magnetizing power of the coil will be the same for all different gauges of wire. The specific conductivity of the copper itself is of importance; for the better the conductivity, the less the heat-waste per cubic inch of winding. High-conductivity copper is therefore to be preferred in every case.

Now the heat which is thus generated by the current of electricity raises the temperature of the coil (and of the core), and it begins to emit heat from its surface. It may be taken as a sufficient approximation that a single square inch of surface, warmed 1° Fahr. above the surrounding air, will steadily emit heat at the rate of $\frac{1}{225}$ of a watt. Or, if there is provided only enough surface to allow of a steady emission of heat at the rate of 1 watt* per square inch of surface, the temperature of that surface will rise to about 225° Fahr. above the temperature of the surrounding air. This number is determined by the average emissivity of such substances as cotton, silk, varnish, and other materials of which the surfaces of coils are usually composed.

In the specifications for dynamo machines, it is usual to lay down a condition that the coils shall not heat more than a certain number of degrees warmer than the air. With electromagnets it is a safe rule to say that no electromagnet ought ever to heat up to a temperature more than 100° Fahr. above the surrounding air. In many cases it is quite safe to exceed this limit.

The resistance of the insulated copper wire on a bobbin may be approximately calculated by the following rule. If d is the diameter of the naked wire, in mils, and D is the diameter, in mils, of the wire when covered, then the resistance per cubic inch of the coil will be :—

$$\text{Ohms per cub. inch} = \frac{960{,}700}{D^2 \times d^2}.$$

We are therefore able to construct a wire-gauge and amperage table which will enable us to calculate readily the degree to which a given coil will warm when traversed by a given current, or conversely what volume of coil will be needed to provide the requisite circulation of current without warming beyond any prescribed excess.

Accordingly, I here give a *Wire-Gauge and Amperage Table* (p. 932), which we have been using for some time at the Finsbury Technical College. It was calculated out under my instructions by one of the Demonstrators of the College, Mr. Eustace Thomas, to whom I am indebted for the great care bestowed upon the calculations.

For many purposes, such as for use in telegraphs and electric bells, smaller wires than any of those mentioned in the Table are required. The Table is, in fact, intended for use in calculating magnets in larger engineering work.

A rough and ready rule sometimes given for the size of wire is to allow $\frac{1}{1000}$ square inch per ampere. This is an absurd rule, however, as the figures in the Table show. Under the heading 1,000 amperes to square inch, it appears that if a No. 18 S.W.G. wire is used, it will at that rate carry 1·81 amperes; that if there is only one layer of wire, it will only warm up 4·64° Fahr., consequently one might wind layer after layer to a depth of 3·3 inches, without getting up to the limit of allowing one square inch per watt, for the emission of heat. In very few cases does one want to wind a coil so thick as 3·3 inches. For very few electromagnets is it needful that the layer of coil should exceed $\frac{1}{2}$ an inch in thickness; and if the layer is going to be only $\frac{1}{2}$ an inch thick, or about $\frac{1}{7}$ of the 3·3, one may use a current density $\sqrt{7}$ times as great as 1,000 amperes per square inch, without exceeding the limit of safe working. Indeed, with coils only $\frac{1}{2}$ inch thick, one may safely employ a current density of 3,000 amperes per square inch, owing to the assistance which the core gives for the dissipation and emission of heat.

Suppose, then, we have designed a horseshoe magnet, with a core 1 inch in diameter, and that after considering the work it has to do, it is found that a magnetizing power of 2,400 turns is required; suppose also that it is laid down as a condition that the coil must not warm up more than 50° Fahr. above the surrounding air—what volume of coil will be required? Assume first that the current will be 1 ampere; then there will have to be 2,400 turns of a wire which will carry 1 ampere. If we took a No. 20 S.W.G. wire, and wound it to a depth of $\frac{1}{2}$ an inch, that would give 220 turns per inch length of coil: so that a coil 11 inches long, and a little over $\frac{1}{2}$-inch deep (or 10 layers deep) would give 2,400 turns. Now Table X. shows that if this wire were to carry 1·018 ampere, it would heat up 225° Fahr., if wound to a depth of 3·9 inches. If wound to $\frac{1}{2}$-inch, it would therefore heat up about 30° Fahr.; and with only 1 ampere would of course heat less. This is too good; try the next thinner wire. No. 22, S.W.G. wire, at 2,000 amperes to square inch, will carry 1·23 amperes; and heats 225° if wound up 1·13 inches. If it is only to heat 50° it must not be wound more than $\frac{1}{4}$-inch deep; but if it only carries current of 1 ampere it may be wound a little deeper—say to 14 layers. There will then be

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* The *watt* is the unit of rate of expenditure of energy, and is equal to ten million ergs per second, or to 1-746th of a horse-power. A current of one ampere, flowing through a resistance of one ohm, spends energy in heating at the rate of one watt. One watt is equivalent to 4·2 calories per second, of heat. That is to say, the heat developed in one second, by expenditure of energy at the rate of one watt, would suffice to warm one gramme of water through 4·2 (Centigrade) degrees. As 252 calories are equal to one British (lb. Fahrenheit) unit of heat, it follows that heat emitted at the rate of one watt would suffice to warm 17½ pounds of water one degree Fahrenheit in one minute; or one British unit of heat equals 1,058 watt-seconds.

TABLE X.—WIRE GAUGE AND AMPERAGE TABLE.

DIMENSIONS.					PERMISSIBLE AMPERAGE, PROBABLE HEATING, AND PERMISSIBLE DEPTH.											
S. W. G.	Diam. (inch.)	Section. (sq. inch bare.)	Turns to 1 linear inch. (covered.)	Turns per sq. inch. (covrd.)	At 1,000 Amps. to sq. inch.			At 2,000 Amps. to sq. inch.			At 3,000 Amps. to sq. inch.			At 4,000 Amps. to sq. inch.		
					A	F	D	A	F	D	A	F	D	A	F	D
22	·028	·00062	23·81	624·	·616	2·28	4·5	1·23	9·12	1·13	1·85	20 52	·50	2·46	36·5	·28
20	·036	·0010	20·00	440·	1·018	3·18	3·9	2·036	12·72	·97	3·05	28·62	·43	4·07	50·9	·24
19	·040	·0012	18·52	377	1·26	3·56	3·6	2·52	14·24	·92	3·78	32·04	·41	5·04	57·0	·23
18	·048	·0018	16·13	286·	1·81	4·64	3·3	3·62	18·56	·83	5·43	41·76	·37	7·24	74·2	·21
17	·056	·0024	14·28	224	2·4	5·47	3·2	4·8	21·9	·79	7·2	49·2	·35	9·6	87·5	·19
16	·064	·0032	12·83	181	3·2	6·57	3·0	6·4	26·3	·74	9·6	59·1	·33	12·8	105·1	·18
15	·072	·0040	11·63	149	4·0	7·40	2·9	8·0	29·6	·72	12·0	66·6	·32	16·0	118·4	·17
14	·080	·0050	10·64	124	5·0	8·46	2·8	10·0	33·8	·70	15·0	76·3	·31	20·0	135·4	·17
13	·092	·0060	9·44	98·2	6·6	9·97	2·7	13·2	39·9	·67	19·8	89·7	·30	26·4	159·5	·16
12	·104	·0085	8·48	79·1	8·5	11·53	2·6	17·0	46·1	·65	25·5	103·8	·29	34·0	184·4	·16
11	·116	·0105	7·69	65·0	10·5	12·8	2·5	21·0	51·2	·63	31·5	115·2	·28	42·0	204·8	·16
10	·128	·0128	7·04	54·5	12·8	14·3	2·4	25·6	57·2	·61	38·4	128·7	·27	51·2	228·8	·15
9	·144	·0163	6·33	44·1	16·3	16·4	2·4	32·6	65·6	·60	48·9	147·6	·27	65·2	262·4	·15
8	·160	·0201	5·74	36·3	20·1	18·4	2·3	40·2	73·6	·59	60·3	165·6	·26	80·4	294·4	·15
7	·176	·0243	5·26	30·4	24·3	20·4	2·3	48·6	81·6	·58	72 9	183·6	·26	97·2	326·4	·15
Stranded.																
7/22	0·84	·0043	9·62	101·8	4·3	6·73	4·0	8·6	26·9	·99	12·9	24·6	·44	17·2	107·7	·25
7/20	·108	·0072	7·81	67·1	7·13	8·94	3·7	14·3	35·7	·92	21·4	80·5	·48	28·5	143·0	·23
7/18	·144	·0128	6·09	40·8	12·7	12·4	3·4	25·4	49·6	·83	38·1	111·6	·39	50·8	198·4	·21
7/16	·192	·0229	5·10	28·6	22·9	17·2	3·2	45·8	68·7	·79	68·7	154·5	·35	91·6	274·7	·20
7/15	·216	·0289	4·27	20·1	28 9	19·5	3·1	57·8	78·0	·78	86 7	175·4	·34	115·6	311·8	·20
7/14	·240	·0356	3·87	16·5	35·6	21·8	3·1	71·2	87·1	·76	106·8	195·9	·34	142·4	348·3	·19
7/13	·276	·0462	3 38	12·6	46·2	24·7	3·0	92.4	98·8	·74	138·6	222·3	·33	184·8	395·2	·19
7/12	·312	·0595	3·01	9·97	59·5	28·5	2·9	179·0	114·0	·72	178·5	256·5	·32	238·0	456·	·18

Figures in columns marked A signify number of ampères that the wire carries.

Figures in columns marked F signify number of degrees (Fahrenheit) that the coil will warm up if there is only one layer of wire, and on the assumption that the heat is radiated only from the outer surface of the coil: they are calculated by the following modification of Forbes's rule:—

Rise in temperature (Fahrenheit degrees) = 225 × No. of watts lost per sq. inch.
= 159 × sectional area × number of turns to 1 inch (at 1,000 Amps. per sq. inch).

Figures in columns marked D are the depths in inches to which wire may be wound if 1 watt be lost by each square inch of radiating surface, the outside radiating surface of the bobbin being only considered.

Rule for calculating a 7-strand cable:—Diam. of cable = 1·134 × diam. of equivalent round wire.

Figures under heading "Turns to 1 linear inch" are calculated for cotton-covered wires of average thicknesses of coverings used for the different gauges, viz., 14 mils additional diameter on round wires (from No. 22), and 20 mils on stranded or square wire.

Figures under heading "Turns per square inch" are calculated from preceding, allowing 10 per cent. for bedding of layers.

Resistance (ohms) of coil of copper wire, occupying *v* cubic inches of coil-space, and of which the gauge is *d* mils uncovered, and D mils covered, may be approximately calculated by the rule:—

$$\text{ohms} = 960700 \frac{v}{D^2 d^2}$$

The data respecting sizes of wires of various gauges are kindly furnished by the London Electric Wire Company.

wanted a coil about 7 inches long to hold the 2,400 turns. The wire will occupy about 3·85 square inches of total cross section; and the volume of the space occupied by the winding will be 26·95 cubic inches. Two bobbins, each $3\frac{1}{2}$ inches long and ·65 deep, to allow for 14 layers, will be suitable to receive the coils.

By the light of the knowledge one possesses as to the relation between emissivity of surface, rate of heating by current, and limiting temperatures, it is seen how little justification there is for such empirical rules as that which is often given, namely, to make the depth of coil equal to the diameter of the iron core. Consider this in relation to the following fact; that in all those cases where leakage is negligible, the number of ampere-turns that will magnetize up a thin core to any prescribed degree of magnetization will magnetize up a core of any section whatever, and of the same length, to the same degree of magnetization. A rule that would increase the depth of copper proportionately to the diameter of the iron core is absurd.

Where less accurate approximations are all that is needed, more simple rules can be given. Here are two cases:—

Case 1. *Leakage assumed to be negligible.*—Assume **B** = 16,000, then **H** = 50 (see Table III). Hence the ampere-turns per centim. of iron will have to be 40, or per inch of iron, 102; for **H** is equal to 1·2566 times the ampere-turns per centimetre. Now if the winding is not going to exceed $\frac{1}{2}$-inch in depth, we may allow 4,000 amperes per square inch without serious over-heating. And the 4,000 ampere-turns will require 2-inch length of coil, or each inch of coil carries 2,000 ampere-turns without over-heating. Hence each inch of coil $\frac{1}{2}$-inch deep will suffice to magnetize up 20 inches length of iron to the prescribed degree.

Case 2. *Leakage assumed to be* 50 *per cent.*—Assume **B** in air gap = **H** = 8,000, then to force this across requires ampere-turns 6,400 per centim. of air, or 16,250 per inch of air. Now if winding is not going to exceed $\frac{1}{2}$-inch depth, each inch length of coil will carry 2,000 ampere-turns. Hence, 8 inches length of coil $\frac{1}{2}$-inch deep will be required for 1 inch length of air, magnetized up to the prescribed degree.

WINDINGS FOR CONSTANT PRESSURE AND FOR CONSTANT CURRENT.

In winding coils for magnets that are to be used on any electric light system, it should be carefully borne in mind that there are separate rules to be considered according to the nature of the supply. If the electric supply is at *constant pressure*, as usual for glow lamps, the winding of coils of electromagnets follows the same rule as the coils of voltmeters. If the supply is with *constant current*, as usual for arc lighting in series, then the coils must be wound with due regard to the current which the wire will carry, when lying in layers of suitable thickness, the number of turns being in this case the same whether thin or thick wire is used.

If we assume that a safe limit of temperature is 90° Fahr. higher than the surrounding air, then the largest current which may be used with a given electromagnet is expressed by the formula:—

$$\text{Highest permissible amperes} = 0{\cdot}63\sqrt{\frac{s}{r}}$$

where s is the number of square inches of surface of the coils, and r their resistance in ohms.

Similarly for coils to be used as shunts we have:—

$$\text{Highest permissible volts} = 0{\cdot}63\sqrt{s\,r}$$

The magnetizing power of a coil, supplied at a given number of volts of pressure, is independent of its length, and depends only on its gauge, but the longer the wire the *less* will be the heat waste. On the contrary, when the condition of supply is with a constant number of amperes of current, the magnetizing power of a coil is independent of the gauge of the wire, and depends only on its length; but the larger the gauge the less will be the heat waste.

MISCELLANEOUS RULES ABOUT WINDING.

To reach the same limiting temperature with bobbins of equal size wound with wires of different gauge, the cross-section of the wire must vary with the current it is to carry; or, in other words, the current-density (amperes per square inch) must be the same in each. Table X. shows the amperages of the various sizes of wires, at four different values of current-density.

To raise to the same temperature two similarly-shaped coils, differing in size only, and having the gauges of the wires in the same ratio (so that there are the same number of turns on the large coil as on the small one), the currents must be proportional to the square roots of the cubes of the linear dimensions.

Sir William Thomson has given a useful rule for calculating windings of electromagnets of the same type but of different sizes. Similar iron cores, similarly wound with lengths of wire proportional to the squares of their linear dimensions, will, when excited with equal currents, produce equal intensities of magnetic field at points similarly situated with respect to them.

Similar electromagnets of different sizes must have ampere-turns proportional to their linear dimensions if they are to be magnetized up to an equal degree of saturation.

It is curious what erroneous notions crop up from time to time about winding electromagnets. In 1869, a certain Mr. Lyttle took out a patent for winding the coils in the following way. Wind the first layer as usual, then bring the wire back to the end where the winding began and wind a second layer, and so on. In this way all the windings will be right-handed, or else all left-handed, not alternately right and left as in the ordinary winding. Lyttle declared that this method of winding a coil gave more powerful effects; so did M. Brisson, who re-invented the same mode of winding in 1873, and solemnly described it. Its alleged superiority was at once disproved by Mr. W. H. Preece, who found the only difference to be that there was more difficulty in carrying out this mode of winding.

Another popular error is that electromagnets in which the wires are badly insulated are more powerful than those in which they are well insulated. This arose from the ignorant use of electromagnets having long thin coils (of high resistance) with batteries consisting of a few cells (of low electromotive force). In such cases, if some of the coils are short-circuited, more current flows, and the magnetizing power may be greater. But the scientific cure is either to re-wind the magnet with an appropriate coil of thick wire, or else to apply another battery having an electromotive force that is greater.

SPECIFICATIONS OF ELECTROMAGNETS.

One frequently comes across specifications for construction which prescribe that an electromagnet shall be wound so that its coil shall have a certain resistance. This is an absurdity. Resistance does not help to magnetize the core. A better way of prescribing the winding is to name the ampere-turns and the temperature limit of heating. Another way is to prescribe the number of watts of energy which the magnet is to take. Indeed it would be well if electricians could agree upon some sort of figure of merit by which to compare electromagnets, which should take into account the magnetic output—*i.e.*, the product of magnetic flux into magneto-motive force—the consumption of energy in watts, the temperature rise, and the like.

AMATEUR RULE ABOUT RESISTANCE OF ELECTROMAGNET AND BATTERY.

In dealing with this question of winding copper on a magnet core, I cannot desist from referring to that rule which is so often given, which I often wish might disappear from our text-books—the rule which tells you in effect that you are to waste 50 per cent. of the energy you employ. I refer to the rule which states that you will get the maximum effect out of an electromagnet if you so wind it that the resistance is equal to the resistance of the battery you employ; or that if you have a magnet of a given resistance you ought to employ a battery of the same resistance. What is the meaning of this rule? It is a rule which is absolutely meaningless unless in the first case the volume of the coil is prescribed once for all, and you cannot alter it, or unless once for all the number of battery elements that you can have is prescribed. If you have to deal with a fixed number of battery elements, and you have to get out of them the biggest effect in your external circuit, and cannot beg, buy, or borrow any more cells, it is perfectly true that, for steady currents, you ought to group them so that their internal resistance is equal to the external resistance that they have to work through; and then, as a matter of fact, half the energy of the battery will be wasted, but the output will be a maximum. Now that is a very nice rule indeed for amateurs, because an amateur generally starts with the notion that he does not want to economise in his rate of working; it does not matter whether the battery is working away furiously, heating itself, and wasting a lot of power; all he wants is to have the biggest possible effect for a little time out of the fewest cells. It is purely an amateur's rule, therefore, about equating the resistance inside to the resistance outside. But it is absolutely fallacious to set up any such rule for serious working; and not only fallacious, but absolutely untrue if you are going to deal with currents that are going to be turned off and on quickly. For any apparatus like an electric bell, or rapid telegraph, or induction coil, or any of those things where the current is going to vary up and down rapidly, it is a false rule, as we shall see presently. What is the real point of view from which one ought to start? I am often asked questions by, shall I say, amateurs as well as by those who are not amateurs, about prescribing the battery for a given electromagnet, or prescribing an electromagnet for a given battery. Again, I am often told of cases of failure in which a very little common sense rightly directed might have made a success. What one ought to think about in every case is not the battery, not the electromagnet, but *the line*. If you have a line, then you must have a battery and electromagnet to correspond. If the line is short and thick, a few feet of good copper wire, you should have a short thick battery (a few big cells, or one big cell), and a short thick coil on your electromagnet. If you have a long thin line, miles of it, say, you want a long thin battery (small cells, and a long row of them) and a long thin coil. That is then our rule; for a short thick line, a short thick battery, and a short thick coil; for a long thin line, a long thin battery; and electromagnet coils to match. You smile: but it is a really good rule that I am giving you; vastly better than the worn-out amateur rule.

But, after all, my rule does not settle the whole question, because there is something more than the whole resistance of the circuit to be taken into account. Whenever you come to rapidly-acting apparatus, you have to think of the fact that the current, while varying, is governed not so much by the resistance as by the inertia of the circuit—its electromagnetic inertia. As this is a matter which will claim our especial attention hereafter, I will leave battery rules for the present, and proceed with the question of design.

FORMS OF ELECTROMAGNETS.

This at once leads us to consider the classification of forms of magnets. I do not pretend to have found a complete classification. There is a very singular book written by Mons. Nicklès, in which he classifies under 37 different heads all conceivable kinds of magnets, bidromic, tridromic, monocnemic, multidromic, and I do not know how many more; but the classification is both unmeaning and unmanageable. For my present purpose I will simply pick out those which come under three or four heads, and deal separately with others that do not quite fit under any of the four categories.

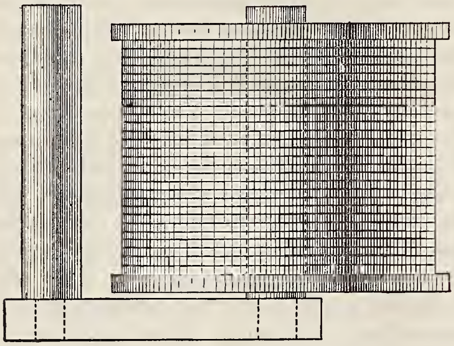
Bar Electromagnets.—In the first place there are those which have a straight core, of which there are several specimens on the table here.

Horse-shoe Electromagnets.—Then there are the horse-shoes, of which some are of one piece bent, and others are of the more frequent shape, made of three pieces.

Iron-clad Electromagnets,—Then from the horse-shoes I go to those magnets in which the return circuit of the iron comes back outside the coil either from one end or the other, or from both ends, sometimes in the form of an external tube or jacket, sometimes merely with a parallel return yoke, or two parallel return yokes. All such magnets I propose to call—following the fashion that has been adopted for dynamos—iron-clad electromagnets. One of them, the jacketted electromagnet, is shown in Fig. 12 (p. 878), and there are others not so well known. There is one used by Mr. Cromwell Varley, in which a straight magnet is placed between a couple of iron caps, which fit over the ends, and virtually bring the poles down close together; the circular rim of one cap being the north pole, and that of the other cap being the south pole, the two rims being close together. That plan of course produces a great tendency to leak across from one rim to the other all round. The advantages, as well as the disadvantages, of the jacketted magnet I alluded to in my last lecture, when I pointed out to you that for all action at a distance it is far better not to have an iron-clad return path, whereas for action in contact the iron-clad magnet was distinctly a very good form. In one form of iron-clad magnet the end of the straight central core is fixed to the middle of a bar of iron, the ends of which are bent up and brought flush with the top of the bobbin, making thus a tripolar magnet, with one pole between the other two. The armature in this form is a bar which lies right across the three poles. There is an example of this excellent kind of electromagnet applied in one of the forms of electric bell indicator made by Messrs. Gent, of Leicester.

Then besides these three main classes—the straight bar, the horse-shoe, and the iron-clad—there is another form which is so useful, and so commonly employed in certain work that it deserves to have a name of its own. It is that called by Count Du Moncel the *aimant boîteux*, or club-footed magnet (Fig. 50, p. 936). It is a horse-shoe in fact, with a coil upon one pole and no coil upon the other. The advantage of that construction is simply, I suppose, that you will save labour—you will only have to wind the wire on one pole instead of two. Whether that is an improvement in any other sense is a question for experiment to determine; but on which theory perhaps might now be able to ay something. Count Du Moncel, who made many experiments on this form of magnet, ascertained that there was for an equal weight of copper a slight falling off in power with the club-footed magnet. Indeed one might almost predict, for a given weight of copper, if you wound all in one coil only, you will not make as many turns as if you wound it in two; the outer turns on the coil being so much larger than the average turn when wound in two coils. Consequently the number of ampere-urns with a given weight of copper would be ather smaller, and you would require more current to bring the magnetizing power up to he same value as with the two coils. At the same time the one coil may be produced a ittle more cheaply than the two; and indeed uch electromagnets are really quite common, being largely used, for the sake of cheapness and compactness, in indicators of electric bells.

Fig. 50.



Club-footed Electromagnet.

Du Moncel tried various experiments about his form to find whether it acted better when the armature was pivotted over one pole or over the other, and found it worked best when he armature was actually hinged on to that pole which comes up through the coil. He made two experiments, trying coils on one or other limb, the armature being in each case set at an equal distance. In one experiment e found the pull was 35 grammes, with an armature hinged on to the idle pole, and 40 grammes when it was hinged on to the pole which carried the coil.

Another form of electromagnet, having but one coil, is used in the electric bells of church-ell pattern, of which Mr. H. Jensen is the d esigner. In Jensen's electromagnet a straight cylindrical core receives the bobbin for the coil, and, after this has been pushed into its place, two ovate pole-pieces are screwed upon its ends, serving thus to bring the magnetic circuit across the ends of the bobbin, and forming a magnetic gap along the side of the bobbin. The armature is a rectangular strip of soft iron, about the same length as the core, and is attracted at one end by one pole-piece, and at the other end by the other.

Effect of Size of Coils.

Seeing that the magnetizing power which a coil exerts on the magnetic circuit which it surrounds is simply proportional to the ampere-turns, it follows that those turns which lie on the outside layers of the coil, though they are further away from the iron core, possess precisely equal magnetizing power. This is strictly true for all closed magnetic circuits; but in those open magnetic circuits where leakage occurs it is only true for those coils which encircle the leakage lines also. For example, in a short bar electromagnet, of the wide turns on the outer layer, those which encircle the middle part of the bar do enclose all the magnetic lines, and are just as operative as the smaller turns that underlie them; whilst those wide turns which encircle the end portions of the bar are not so efficient, as some of the magnetic lines leak back past these coils.

Effect of Position of Coils.

Among the other researches which Du Moncel made with respect to electromagnets, was one on the best position for placing the coil upon the iron core. This is a matter that other experimenters have examined. In Dub's book, "Electromagnetismus," to which I have several times referred, you will also find many experiments on the best position of a coil; but it is perhaps sufficient to narrate a single example. Du Moncel had four pairs of bobbins made of exactly the same length, and with 50 metres of wire on each, one pair was 16 centimetres long, another pair 8 centimetres, or half the length, with not quite so many turns, because of course the diameter of the outer turns was larger, one 4 centimetres in length and another 2 centimetres. These were tried both with bar magnets and horseshoes. It will suffice perhaps to give the result of the horseshoe. The horshoe was made long enough—16 centimetres only, a little over 6 inches long—to carry the longest coil. Now when the compact coils 2 centimetres long were used, the pull on the armature at a distance away of 2 millimetres (it was always the same of course in the experiments) was 40 grammes. Using the same weight of wire, but distributed on the coils twice as long, the pull was 55 grammes. Using the coils 8 centimetres long, it was 75 grammes; and using the coils 16 centimetres long, covering the length of each limb, the pull was 85, clearly showing that, where you have a given length of iron, the best way of winding a magnet to make it pull with its greatest pull is not to heap the coil up against the poles, but to wind it uniformly, for this mode of winding will give you more turns, therefore more ampere-turns, therefore more magnetization. An exception might, however, occur in some case where there is a large percentage of leakage. With club-footed magnets results of the same kind are obtained. It was found in every case that it was well to distribute the coil as much as possible along the length of the limb. All these experiments were made with a steady current. It does not follow, however, because winding the wire over the whole length of core is best for steady currents that it is the best winding in the case of a rapidly varying current; indeed, we shall see that it is not.

EFFECT OF SHAPE OF SECTION.

So far as the carrying capacity for magnetic lines is concerned, one shape of section of cores is as good as another; square or rectangular is as good as round if containing equal sectional area. But there are two other reasons, both of which tell in favour of round cores. First, the leakage of magnetic lines, from core to core is, for equal mean distances apart, proportional to the surface of the core; and the round core has less surface than square or rectangular of equal section. All edges and corners, moreover, promote leakage. Secondly, the quantity of copper wire that is required for each turn will be less for round cores than for cores any other shape, for of all geometrical figures of equal area the circle is the one of the least periphery.

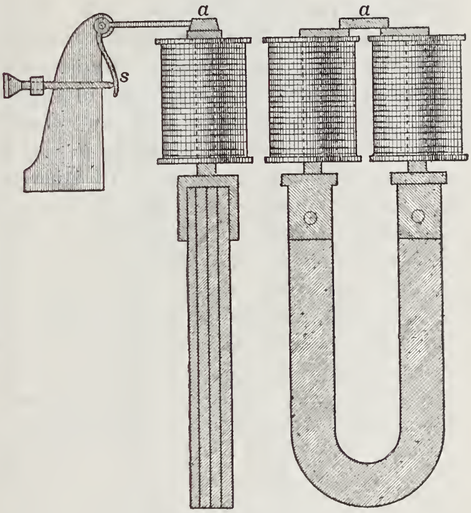
EFFECT OF DISTANCE BETWEEN POLES.

Another matter that Du Moncel experimented upon, and Dub and Nicklès likewise, was the distance between the poles. Dub considered that it made no difference how far the poles were apart. Nicklès had a special arrangement made which permitted him to move the two upright cores or limbs, 9 centimetres high, to and fro on a solid bench or yoke of iron. His armature was 30 centimetres long. Using very weak currents he found the effect best when the shortest distance between the poles was 3 centimetres; with a stronger current 12 centimetres; and with his strongest current nearly 30 centimetres. I think leakage must have a deal to do with these results. Du Moncel tried various experiments to elucidate this matter, and so did Professor Hughes, in an important, but too little-known, research which came out in the "Annales Télégraphiques" in the year 1862.

RESEARCHES OF PROFESSOR HUGHES.

His object was to find out the best form of electromagnet, the best distance between the poles, and the best form of armature for the rapid work required in Hughes's printing telegraphs. One word about Hughes's magnets. This diagram (Fig. 51) shows the form of the well-known Hughes's electromagnet. I feel almost ashamed to say those words "well-known," because although on the Continent everybody knows what you mean by a Hughes's electromagnet, in England scarcely any one knows what you mean. Englishmen do not even know that Professor Hughes has invented a special form of electromagnet. Hughes's special form is this:—A permanent steel magnet, generally a compound one, having soft iron pole-pieces, and a couple of coils on the pole-pieces only. As I have to speak of Hughes's special contrivance amongst

FIG. 51.



HUGHES'S ELECTROMAGNET.

the mechanisms that will occupy our attention next week, I only now refer to this magnet in one particular. If you wish a magnet to work rapidly, you will secure the most rapid action not when the coils are distributed all along but when they are heaped up near, not necessarily entirely on, the poles. Hughes made a number of researches to find out what the right length and thickness of these pole-pieces should be. It was found an advantage not to use too thin pole-pieces, otherwise the magnetism from the permanent magnet did not pass through the iron without considerable reluctance, being choked by insufficiency of section; also not to use too thick pieces, otherwise they presented too much surface for leakage across from one to the other. Eventually a particular length was settled upon, in proportion about six times the diameter, or rather longer. In the further researches that Hughes made he used a magnet of shorter form, not shown here, more like those employed in relays, and with an armature from 2 to 3 millimetres thick, 1 centimetre wide, and 5 centimetres long. The poles were turned over at the top towards one another. Hughes tried whether there was any advantage in making those poles approach one another, and whether there was any advantage in having as long an armature as 5 centimetres. He tried all different kinds, and plotted out the results of observations in curves, which could be compared and studied. His object was to ascertain the conditions which would give the strongest pull, not with a steady current but with such currents as were required for operating his printing telegraph instruments; currents which lasted but one to twenty hundredths of a second. He found it was decidedly an advantage to shorten the length of the armature, so that it did not protrude far over the poles. In fact he got a sufficient magnetic circuit to secure all the attractive power that he needed, without allowing as much chance of leakage as there would have been had the armature extended a longer distance over the poles. He also tried various forms of armature having very various cross-sections.

Position and Form of Armature.

In one of Du Moncel's papers on electromagnets* you will also find a discussion on armatures, and the best forms for working in different positions. Amongst other things in Du Moncel you will find this paradox; that whereas using a horseshoe magnet with flat poles, and a flat piece of soft iron for armature, it sticks on far tighter when put on edgeways; on the other hand, if you are going to work at a distance, across air, the attraction is far greater when it is set flatways. I explained the advantage of narrowing the surfaces of contact by the law of traction, $\mathbf{B}^2$ coming in. Why should we have for an action at a distance the greater advantage from placing the armature flatway to the poles? It is simply that you thereby reduce the reluctance offered by the air gap, to the flow of the magnetic lines. Du Moncel also tried the difference between round armatures and flat ones, and found that a cylindrical armature was only attracted about half as strongly as a prismatic armature, having the same surface when at the same distance. Let us examine this fact in the light of the magnetic circuit. The poles are flat. You have at a certain distance away a round armature; there is a certain distance between its nearest side and the polar surfaces. If you have at the same distance away a flat armature having the same surface, and, therefore, about the same tendency to leak, why do you get a greater pull in this case than in that? I think it is clear that if they are at the same distance away, giving the same range of motion, there is a greater magnetic reluctance in the case of the round armature, although there is the same periphery, because though the nearest part of the surface is at the prescribed distance, the rest of the under surface is farther away; so that the gain found in substituting an armature with a flat surface is a gain resulting from the diminution in the resistance offered by the air gap.

Pole-Pieces on Horse-shoe Magnets.

Another of Du Moncel's researches* relates to the effect of polar projections or shoes—moveable pole-pieces, if you like—upon a horse-shoe electromagnet. The core of this magnet was of round iron 4 centimetres in diameter, and the parallel limbs were 10 centimetres long and 6 centimetres apart. The shoes consisted of two flat pieces of iron slotted out at one end, so that they could be slid along over the poles and brought nearer together. The attraction exerted on a flat armature across air gaps 2 millimetres thick was measured by counterpoising. Exciting this electromagnet with a certain battery, it was found that the attraction was greatest when the shoes were pushed to about 15 millimetres, or about ¼ of the inter-polar distance, apart. The numbers were as follows :—

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* "La Lumière Electrique," vol. ii.

* "La Lumière Electrique," vol. iv., p. 129.

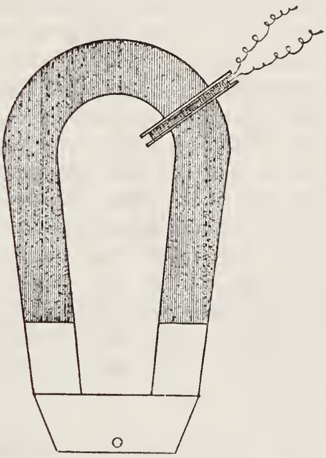
Distance between shoes. Millimetres.	Attraction, in grammes.
2	900
10	1,012
15	1,025
25	965
40	890
60	550

With a stronger battery the magnet without shoes had an attraction of 885 grammes, but with the shoes 15 millimetres apart, 1,195 grammes. When one pole only was employed, the attraction, which was 88 grammes without a shoe, was *diminished* by adding a shoe to 39 grammes!

CONTRAST BETWEEN ELECTROMAGNETS AND PERMANENT MAGNETS.

Now I want particularly to ask you to guard against the idea that all these results obtained from electromagnets are equally applicable to permanent magnets of steel; they are not, for this simple reason. With an electromagnet, when you put the armature near, and make the magnetic circuit better, you not only get more magnetic lines going through that armature, but you get more magnetic lines going through the whole of the iron. You get more magnetic lines round the bend when you put an armature on to the poles, because you have a magnetic circuit of less reluctance, with the same external magnetizing power in the coils acting around it. Therefore, in that case, you will have a greater magnetic flux all the way round. The data obtained with the electromagnet (Fig. 42), with the exploring coil, C, on the bend of the core, when the armature was in contact, and when it was removed, are most significant. When the armature was present it multiplied the total magnetic flow tenfold for weak currents, and nearly threefold for strong currents. But with a steel horseshoe, magnetized once for all, the magnetic lines that flow around the bend of the steel are a fixed quantity, and however much you diminish the reluctance of the magnetic circuit you do not create or evoke any more. When the armature is away the magnetic lines arch across, not at the ends of the horseshoe only, but from its flanks; the whole of the magnetic lines leaking somehow across the space. When you have put the armature on, these lines, instead of arching out into space as freely as they did, pass for the most part along the steel limbs and through the iron armature. You may still have a considerable amount of leakage, but you have not made one line more go through the bent part. You have absolutely the same number going through the bend with the armature off as with the armature on. You do not add to the total number by reducing the magnetic reluctance, because you are not working under the influence of a constantly impressed magnetizing force. By putting the armature on to a steel horseshoe magnet you only *collect* the magnetic lines, you do not *multiply* them. This is not a matter of conjecture. A group of my students have been making experiments in the following way. They took this large steel horseshoe magnet (Fig. 52), the length of which from end to end through the steel is 42½ inches. A light narrow frame was constructed so that it could be slipped on over the magnet, and on it were wound 30 turns of fine wire, to serve as an exploring coil. The ends of this coil were carried to a distant part of the laboratory, and connected to a sensitive ballistic galvanometer. The mode of experimenting is as follows:—The coil is slipped on over the magnet (or over its armature) to any desired position. The armature of the magnet is placed gently upon the poles, and time enough is allowed to elapse for the galvanometer needle to settle to zero. The armature is then suddenly detached. The first swing measures the change, due to removing the armature, in the number of magnetic lines that

FIG. 52.



EXPERIMENT WITH PERMANENT MAGNET.

pass through the coil in the particular position.

I will roughly repeat the experiment before you: the spot of light on the screen is reflected from my galvanometer at the far end of the table. I place the exploring coil just over the pole, and slide on the armature; then close the galvanometer circuit. Now I detach the armature, and you observe the large swing. I shift the exploring coil, right up to the bend; replace the armature; wait until the spot of light is brought to rest at the zero of the scale. Now, on detaching the armature, the movement of the spot of light is quite imperceptible. In our careful laboratory experiments, the effect was noticed inch by inch all along the magnet. The effect when the exploring coil was over the bend was not as great as 1-3000th part of the effect when the coil was hard up to the pole. We are therefore justified in saying that the number of magnetic lines in a permanently magnetized steel horseshoe magnet is not altered by the presence or absence of the armature.

You will have noticed that I always put on the armature gently. It does not do to slam on the armature: every time you do so, you knock some of the so-called permanent magnetism out of it. But you may pull off the armature as suddenly as you like. It does the magnet good rather than harm. There is a popular superstition that you ought never to pull off the keeper of a magnet suddenly. On investigation, it is found that the facts are just the other way. You may pull off the keeper as suddenly as you like; but you should never slam it on.

From these experimental results I pass to the special design of electromagnets for special purposes.

Electromagnets for Maximum Traction.

These have already been dealt with in the preceding lecture; the characteristic feature of all the forms suitable for traction being the compact magnetic circuit.

Several times it has been proposed to increase the power of electromagnets by constructing them with intermediate masses of iron between the central core and the outside, between the layers of windings. All these constructions are founded on fallacies. Such iron is far better placed either right inside the coils or right outside them, so that it may properly constitute a part of the magnetic circuit. The constructions known as Camacho's and Cance's, and one patented by Mr. S. A. Varley in 1877, belonging to this delusive order of ideas, are now entirely obsolete.

Another construction which is periodically brought forward as a novelty is the use of iron windings of wire or strip in place of copper winding. The lower electric conductivity of iron, as compared with copper, makes such a construction wasteful of exciting power. To apply equal magnetizing power by means of an iron coil implies the expenditure of about six times as many watts as need be expended if the coil is of copper.

Electromagnets for Maximum Range of Attraction.

We have already laid down the principle which will enable us to design electromagnets to act at a distance. We want our magnet to project, as it were, its force across the greatest length of air gap. Clearly, then, such a magnet must have a very large magnetizing power, with many ampere-turns upon it, to be able to make the required number of magnetic lines pass across the air resistance. Also it is clear that the poles must not be too close together for its work, otherwise the magnetic lines at one pole will be likely to curl round and take short cuts to the other pole. There must be a wider width between the poles than is desirable in electromagnets for traction.

Electromagnets of Minimum Weight.

In designing an apparatus to put on board a boat or a balloon, where weight is a consideration of primary importance, there is again a difference. There are three things that come into play—iron, copper, and electric current. The current weighs nothing, therefore if you are going to sacrifice everything else to weight, you may have comparatively little iron, but you must have enough copper to be able to carry the electric current; and under such circumstances you must not mind heating your wires nearly red hot to pass the biggest possible current. Provide as little copper as you conveniently can, sacrificing economy in that case to the attainment of your object; but of course you must use fire-proof material, such as asbestos, for insulating, instead of cotton or silk.

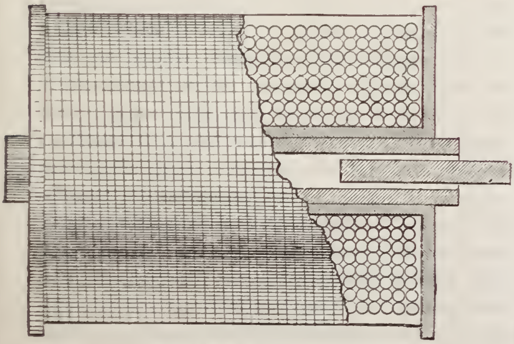
A Useful Guiding Principle.

In all cases of design there is one leading principle which will be found of great assistance, namely, that a magnet always tends so to act as though it tried to diminish the length of its magnetic circuit. It tries to grow more compact. This is the reverse of that which holds good with an electric current. The electric circuit always tries to enlarge itself, so as to enclose as much space as possible, but the magnetic circuit always tries to make itself as compact as possible. Armatures are drawn in as near as can be, to close up the magnetic circuit. Many two-pole electromagnets show a tendency to bend together when the current is turned on. One form in particular, which was devised by Ruhmkorff for the purpose of repeating Faraday's celebrated experiment on the magnetic rotation of polarized light, is liable to this defect. Indeed, this form of electromagnet is often designed very badly, the yoke being too thin, both mechanically and magnetically, for the purpose which it has to fulfil.

Here is a small electric bell, constructed by Wagener of Wiesbaden, the construction of which illustrates this principle. The electromagnet, a horseshoe, lies horizontally; its poles are provided with protruding curved pins of brass. Through the armature are drilled two holes, so that it can be hung upon the two brass pins; and when so hung up it touches the ends of the iron cores just at one edge, being held from more perfect contact by a spring. There is no complete gap, therefore, in the magnetic circuit. When the current comes and applies a magnetizing power it finds the magnetic circuit already complete in the sense that there are no absolute gaps. But the circuit can be bettered by tilting the armature to bring it flat against the polar ends, that being indeed the mode of motion. This is a most reliable and sensitive pattern of bell.

Electromagnetic Pop-gun.—Here is another curious illustration of the tendency to complete the magnetic circuit. Here is a tubular electromagnet (Fig. 53), consisting of a small bobbin, the core of which is an iron tube about two inches long. There is nothing very unusual about it; it will stick on, as you see, to pieces of iron when the current is turned on. It clearly is an ordinary electromagnet in that respect. Now suppose I take a little round rod of iron, about an inch long, and put it into the end of the tube, what will happen when I turn on my current? In this apparatus as it stands, the magnetic circuit consists of a short length of iron, and then all the rest is air. The magnetic circuit will try to complete itself, not by shortening the iron, but by *lengthening* it; by pushing the piece of iron out so as to afford more surface for leakage. That is exactly what happens; for, as you see, when I turn on the current the little piece of iron shoots out and drops down. You see that little piece of iron shoot out with considerable force. It becomes a sort of magnetic pop-gun. This is an experiment which has been twice discovered. I found it first described by Count Du Moncel, in the pages of "La Lumière Electrique," under the name of the "pistolet électromagnétique;" and Mr. Shelford Bidwell invented it independently. I am indebted to him for the use of this apparatus. He gave an account of it to the Physical Society, in 1885, but the reporter missed it, I suppose, as there is no record in the Society's proceedings.

FIG. 53.



ELECTROMAGNETIC POP-GUN.

ELECTROMAGNETS FOR USE WITH ALTERNATING CURRENTS.

When you are designing electromagnets for use with alternating currents, it is necessary to make a change in one respect, namely, you must so laminate the iron that internal eddy-currents shall not occur; indeed, for all rapid acting electromagnetic apparatus it is a good rule that the iron must not be solid. It is not usual with telegraphic instruments to laminate them by making up the core of bundles of iron plates or wires, but they are often made with tubular cores, that is to say, the cylindrical iron core is drilled with a hole down the middle, and the tube so formed is slit with a saw-cut to prevent the circulation of currents in the stance of the tube. Now when electromagnets are to be employed with rapidly alternating currents, such as are used for electric lighting, the frequency of the alternations being usually about 100 periods per second, slitting the cores is insufficient to guard against eddy-currents; nothing short of completely laminating the cores is a satisfactory remedy. I have here, thanks to the Brush Electric

Engineering Company, an electromagnet of the special form that is used in the Brush arc lamp when required for the purpose of working in an alternating current circuit. It has two bobbins that are screwed up against the top of an iron box at the head of the lamp. The iron slab serves as a kind of yoke to carry the magnetism across the top. There are no fixed cores in the bobbins, which are entered by the ends of a pair of yoked plungers. Now in the ordinary Brush lamp for use with a steady current, the plungers are simply two round pieces of iron tapped into a common yoke; but for alternate current working this construction must not be used, and instead a a U-shaped double plunger is used, made up of laminated iron, rivetted together. Of course it is no novelty to use a laminated core; that device, first used by Joule, and then by Cowper, has been re-patented rather too often during the past fifty years to be considered as a recent invention.

The alternate rapid reversals of the magnetism in the magnetic field of an electromagnet, when excited by alternating electric currents, sets up eddy-currents in every piece of undivided metal within range. All frames, bobbin tubes, bobbin ends, and the like, must be most carefully slit, otherwise they will overheat. If a domestic flat-iron is placed on the top of the poles of a properly laminated electromagnet, supplied with alternating currents, the flat-iron is speedily heated up by the eddy-currents that are generated internally within it. The eddy-currents set up by induction in neighbouring masses of metal, especially in good conducting metals such as copper, give rise to many curious phenomena. For example, a copper disk or copper ring placed over the pole of a straight electromagnet so excited is violently repelled. These remarkable phenomena have been recently investigated by Professor Elihu Thomson, with whose beautiful and elaborate researches we have lately been made conversant in the pages of the technical journals. He rightly attributes many of the repulsion phenomena to the lag in phase of the alternating currents thus induced in the conducting metal. The electromagnetic inertia, or self-inductive property of the electric circuit, causes the currents to rise and fall later in time than the electromotive forces by which they are occasioned. In all such cases the impedance which the circuit offers is made up of two things—resistance and inductance. Both these causes tend to diminish the amount of current that flows, and the inductance also tends to delay the flow.

ELECTROMAGNETS FOR QUICKEST ACTION.

I have already mentioned Hughes's researches on the form of electromagnet best adapted for rapid signalling. I have also incidentally mentioned the fact that where rapidly varying currents are employed, the strength of the electric current that a given battery can yield is determined not so much by the resistance of the electric circuit, as by its electric inertia. It is not a very easy task to explain precisely what happens to an electric circuit when the current is turned on suddenly. The current does not suddenly rise to its full value, being retarded by inertia. The ordinary law of Ohm in its simple form no longer applies; one needs to apply that other law which bears the name of the law of Helmholtz, the use of which is to give us an expression, not for the final value of the current, but for its value at any short time, t, after the current has been turned on. The strength of the current after a lapse of a short time, t, cannot be calculated by the simple process of taking the electromotive force and dividing it by the resistance, as you would calculate steady currents.

In symbols, Helmholtz's law is:—

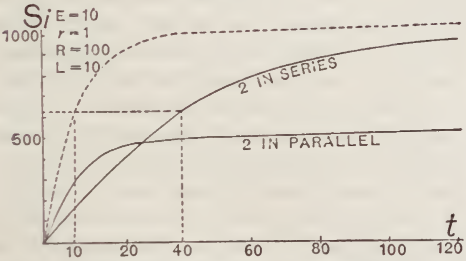
$$i_t = \frac{E}{R}\left(1 - e^{-\frac{R}{L}t}\right).$$

In this formula i_t means the strength of the current after the lapse of a short time t; E is the electromotive force; R the resistance of the whole circuit; L its co-efficient of self-induction; and e the number 2·7183, which is the base of the Napierian logarithms. Let us look at this formula; in its general form it resembles Ohm's law, but with a new factor, namely, the expression contained within the brackets. This factor is necessarily a fractional quantity, for it consists of unity less a certain negative exponential, which we will presently further consider. If the factor within brackets is a quantity less than unity, that signifies that i_t will be less than $E \div R$. Now the exponential of negative sign, and with negative fractional index, is rather a troublesome thing to deal with in a popular lecture. Our best way is to calculate some values, and then plot it out as a curve. When once you have got it into the form of a curve, you can begin to think about it, for the curve gives you a mental picture of the facts that the long formula expresses in the abstract. Accordingly we will take the following case. Let $E = 2$ volts; $R = 1$ ohm; and let us take a relatively large self-induction, so as to exaggerate the effect; say let $L = 10$ quads. This gives us the following:—

$t_{(sec.)}$	$e^{+\frac{R}{L}t}$	i_t
0	1	0
1	1·105	0·950
2	1·221	1·810
5	1·649	3·936
10	2·718	6·343
20	7·389	8·646
30	20·08	9·501
60	403·4	9·975
120	162800·0	9·999

In this case the value of the steady current as calculated by Ohm's law is 10 amperes; but Helmholtz's law shows us that with the great self-induction, which we have assumed to be present, the current, even at the end of 30 seconds, has only risen up to within 5 per cent. of its final value; and only at the end of two minutes has practically attained full strength. These values are set out in the highest curve in Fig. 54, in which, however, the further supposition is made that the number of spirals S in the coils of the electromagnet is 100, so that when the current attains its full value of 10 amperes, the full magnetizing power will be $Si = 1000$. It will be noticed that the curve rises from zero at first steeply and nearly in a straight line, then bends over, and then becomes nearly straight again, as it gradually rises to its limiting value. The first part of the curve—that relating to the strength of the current after *very small* interval of time—is the period within which the strength of the current is governed by inertia (*i.e.*, the self-induction) rather than by resistance. In reality the current is not governed either by the self-induction or by the resistance alone, but by the ratio of the two. This ratio is sometimes called the "time-constant" of the circuit, for it represents *the time* which the current takes in that circuit to rise to a definite fraction of its final value. This definite fraction is the fraction $\frac{e-1}{e}$; or in decimals, 0·634. All curves of rise-of-current are alike in general shape—they differ only in scale; that is to say, they differ only in the height to which they will ultimately rise, and in the time they will take to attain this fraction of their final value.

FIG. 54.



CURVES OF RISE OF CURRENTS.

Example (1).—Suppose $E = 10$; $R = 200$ ohms; $L = 8$. The final value of the current will be 0·025 amp. or 25 milliamperes. Then the time-constant will be $8 \div 400 = 1$-50th sec.

Example (2).—The P.O. Standard "A" relay has $R = 400$ ohms; $L = 3·25$. It works with 0·5 milliampere current, and therefore will work with 5 Daniell cells through a line of 9,600 ohms. Under these circumstances the time-constant of the instrument on short circuit is 0·0081 sec.

It will be noted that the time-constant of a circuit can be reduced either by diminishing the self-induction or by increasing the resistance. In Fig. 54 the position of the time-constant for the top curve is shown by the vertical dotted line at 10 seconds. The current will take 10 seconds to rise to 0·634 of its final value. This retardation of the rise of current is simply due to the presence of coils and electromagnets in the circuit; the current as it grows being retarded because it has to create magnetic fields in these coils, and so sets up opposing electromotive forces that prevent it from growing all at once to its full strength. Many electricians, unacquainted with Helmholtz's law, have been in the habit of accounting for this by saying that there is a lag in the iron of the electromagnet cores. They tell you that an iron core cannot be magnetized suddenly; that it takes time to acquire its magnetism. They think it is one of the properties of iron. But we know that the only true time-lag in the magnetization of iron—that which is properly termed "viscous hysteresis"—does not amount to any great percentage of the whole amount of magnetization, takes comparatively a long time to show itself, and cannot therefore be the cause of the retardation which we are considering. There are also electricians who will tell you that when magnetization is suddenly evoked in an iron bar, there are induction currents set up in the iron which oppose and delay its magnetization. That they oppose the magnetization is perfectly true; but if you carefully laminate the iron so as to eliminate eddy-currents, you will find, strangely enough, that the magnetism rises still more slowly to its final value. For by laminating the iron you have virtually increased the self-inductive action, and increased the time-constant of the circuit, so that the currents rise more slowly than before. The lag is not in the iron, but in the magnetizing current, and the current being retarded, the magnetization is of course retarded also.

CONNECTING COILS FOR QUICKEST ACTION.

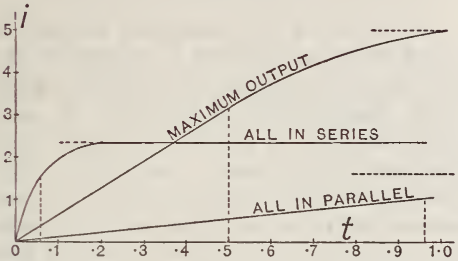
Now let us apply these most important, though rather intricate considerations to the practical problems of the quick working of the electromagnet. Take the case of an electromagnet forming some part of the receiving apparatus of a telegraph system, in which it is desired to secure very rapid working. Suppose the two coils that are wound upon the horse-shoe core are connected together in series. The coefficient of self-induction for these two is four times as great as that of either separately; co-efficients of self-induction being proportional to the square of the number of turns of wire that surround a given core. Now if the two coils, instead of being put in series, are put in parallel, the co-efficient of self-induction will be reduced to the same value as if there were only only one coil, because half the line current (which is practically unaltered) will go through each coil. Hence the time constant of the circuit when the coils are in parallel will be a quarter of that which it is when the coils are in series; on the other hand, for a given line-current, the final magnetizing power of the two coils in parallel is only half what it would be with the coil in series. The two lower curves in Fig. 54 illustrate this, from which it is at once plain that the magnetizing power for very brief currents is greater when the two coils are put in parallel with one another than when they are joined in series.

Now this circumstance has been known for some time to telegraph engineers. It has been patented several times over. It has formed the theme of scientific papers, which have been read both in France and in England. The explanation generally given of the advantage of uniting the coils in parallel is, I think, fallacious; namely that the "extra-currents" (*i.e.*, currents due to self-induction), set up in the two coils are induced in such directions as tend to help one another when the coils are in series, and to neutralise one another when they are in parallel. It is a fallacy, because in neither case do they neutralise one another. Whichever way the current flows to make the magnetism, it is opposed in the coils while the current is rising, and helped in the coils while the current is falling, by the so-called extra-currents. If the current is rising in both coils at the same moment, then whether the coils are in series or in parallel, the effect of self-induction is to retard the rise of the current. The advantage of parallel grouping is simply that it reduces the time-constant.

BATTERY GROUPING FOR QUICKEST ACTION.

One may consider the question of grouping the battery cells from the same point of view. How does the need for rapid working, and the question of time-constant, affect the best mode of grouping the battery cells? The amateur's rule, which tells you to so arrange your battery that its internal resistance should be equal to the external resistance, gives you a result wholly wrong for rapid working. The supposed best arrangement will not give you (at the expense even of economy) the best result that might be got out of the given number of cells. Let us take an example and calculate it out, and place the results graphically before our eyes in the form of curves. Suppose the line and electromagnet have together a resistance of 6 ohms, and that we have 24 small Daniell's cells, each of electromotive force, say, 1 volt, and of internal resistance, 4 ohms. Also let the coefficient of self-induction of the electromagnet and circuit be 6 quadrants. When all the cells are in series the resistance of the battery will be 96 ohms, the total resistance of the circuit 102 ohms, and the full value of the current 0·235 ampere. When all the cells are in parallel the resistance of the battery will be 0·133 ohm, the total resistance 6·133 ohms, and the full value of the current 0·162 ampere. According to the amateur rule of grouping cells so that internal resistance equals external, we must arrange the cells in 4 parallels, each having 6 cells in series, so that the internal resistance of the battery will be 6 ohms, total resistance of circuit 12 ohms, full value of current 0·5 ampere. Now the corresponding time-constants of the circuit in the three cases (calculated by dividing the co-efficient of self-induction by the total resistance) will be respectively—in series, 0·06 sec.; in parallel, 0·5 sec.; grouped for maximum steady current, 0·96 sec. From these data we may now draw the three curves, as in Fig. 55, wherein the abscissæ are the values of time in seconds, and the ordinates the current. The faint vertical dotted lines mark the time-constants in the three cases. It will be seen that when rapid working is required the magnetizing current will rise, during short intervals of time, more rapidly if all the cells are put in series than it will do if the cells are grouped according to the amateur rule.

FIG. 55.



CURVES OF RISE OF CURRENT WITH DIFFERENT GROUPINGS OF BATTERY.

When they are all put in series, so that the battery has a much greater resistance than the rest of the circuit, the current rises much more rapidly, because of the smallness of the time-constant, although it never attains the same ultimate maximum as when grouped in the other way. That is to say, if there is self-induction as well as resistance in the circuit, the amateur rule does not tell you the best way of arranging the battery. There is another mode of regarding the matter which is helpful. Self-induction, while the current is growing, acts as if there were a sort of spurious addition to the resistance of the circuit; and while the current is dying away it acts of course in the other way, as if there were a subtraction from the resistance. Therefore you ought to arrange the battery so that the internal resistance is equal to the real resistance of the circuit, plus the spurious resistance during that time. But how much is the spurious resistance during that time? It is a resistance proportional to the time that has elapsed since the current was turned on. So then it comes to a question of the length of time for which you want to work it. What fraction of a second do you require your signal to be given in? What is the rate of the vibrator of your electric bell? Suppose you have settled that point, and that the short time during which the current is required to rise is called t; then the apparent resistance at time t after the current is turned on is given by the formula:—

$$R_t = R \times e^{\frac{R}{L}t} \div \left(e^{\frac{R}{L}t} - 1\right).$$

TIME-CONSTANTS OF ELECTROMAGNETS.

I may here refer to some determinations made by M. Vaschy,* respecting the coefficients of self-induction of the electromagnets of a number of pieces of telegraphic apparatus. Of these I must only quote one result, which is very significant; it relates to the electromagnet of a Morse receiver of the pattern habitually used on the French telegraph lines.

	L, in quadrants.
Bobbins, separately, without iron cores	0·233 and 0·265.
Bobbins, separately, with iron cores	1·65 and 1·71.
Bobbins, with cores joined by yoke, coils in series	6·37.
Bobbins, with armature resting on poles	10·68.

It is interesting to note how the perfecting of the magnetic circuit increases the self-induction.

Thanks to the kindness of Mr. Preece, I have been furnished with some most valuable information about the coefficients of self-induction, and the resistance of the standard pattern of relays, and other instruments which are used in the British postal telegraph service, from which data one is able to say exactly what the time-constants of those instruments will be on a given circuit, and how long in their case the current will take to rise to any given fraction of its final value. Here let me refer to a very capital paper by Mr. Preece in an old number of the "Journal of the Society of Telegraph Engineers," a paper "On Shunts," in which he treats this question, not as perfectly as it could now be treated with the fuller knowledge we have in 1890 about the coefficients of self-induction, but in a very useful and practical way. He showed most completely that the more perfect the magnetic circuit is—though, of course, you are getting more magnetism from your current—the more is that current retarded. Mr. Preece's mode of experiment was extremely simple; he observed the throw of the galvanometer, when the circuit which contained the battery and the electromagnet was opened by a key which at the same moment connected the electromagnet wires to the galvanometer. The throw of the galvanometer was assumed to represent the extra-current which flowed out. Fig. 56 represents a few of the results of Mr. Preece's paper. Take from an ordinary relay a coil, with its iron core, half the electromagnet, so to speak, without any yoke or armature. Connect it up as described, and observe the throw given to the galvanometer. The amount of throw obtained from the single coil was taken as unity, and all others were compared with it. If you join up two such coils as they are usually joined, in series, but without any iron yoke across the cores, the throw was 17. Putting the iron yoke across the cores, to constitute a horseshoe form, 496 was the throw; that is to say, the tendency of this electromagnet to retard the current was 496 times as great as that of the simple coil. But when an armature was put over the top the effect ran up to 2238. By the mere device of putting the coils in parallel, instead of in series, the 2238 came down to 502, a little less than the quarter value which would have been expected. Lastly, when the armature and yoke were both of them split in the middle, as is done in fact in all the standard patterns of the British Postal Telegraph relays, the throw of the galvanometer was brought down from 502 to 26. Relays so constructed will work excessively rapidly. Mr. Preece states that with the old pattern of relay having so much self-induction as to give a galvanometer throw of 1688, the speed of signalling was only from 50 to 60 words per minute; whereas, with the standard relays constructed on the new plan, the speed of signalling is from 400 to 450 words per minute. It is a very interesting and beautiful result to arrive at from the experimental study of these magnetic circuits.

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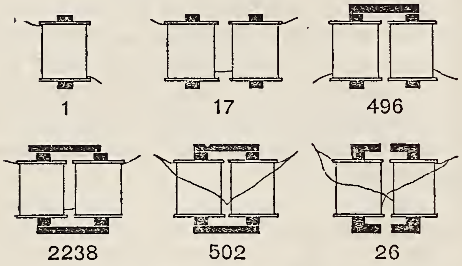
* "Bulletin de la Société Internationale des Electriciens," 1886.

Fig. 56.



Electromagnets of Relay, and their effects.

Short Cores *versus* Long Cores.

In considering the forms that are best for rapid action, it ought to be mentioned that the effects of hysteresis in retarding changes in the magnetization of iron cores are much more noticeable in the case of nearly-closed magnetic circuits than in short pieces. Electromagnets with iron armatures in contact across their poles will retain, after the current has been cut off, a very large part of their magnetism, even if the cores be of the softest of iron. But so soon as the armature is wrenched off the magnetism disappears. An air-gap in a magnetic circuit always tends to hasten demagnetizing. A magnetic circuit composed of a long air-path and a short iron-path demagnetizes itself much more rapidly than one composed of a short air-path and a long iron-path. In long pieces of iron the mutual action of the various parts tends to keep in them any magnetization that they may possess; hence they are less readily de-magnetized. In short pieces, where these mutual actions are feeble or almost absent, the magnetization is less stable, and disappears almost instantly on the cessation of the magnetizing force. Short bits and small spheres of iron have no "magnetic memory." Hence the cause of the commonly received opinion amongst telegraph engineers that for rapid work electromagnets must have short cores. As we have seen, the only reason for employing long cores is to afford the requisite length for winding the wire which is necessary for carrying the needful circulation of current to force the magnetism across the air-gaps. If, for the sake of rapidity of action, length has to be sacrificed, then the coils must be heaped up more thickly on the short cores. The electromagnets in American patterns of telegraphic apparatus usually have shorter cores, and a relatively greater thickness of winding upon them, than those of European patterns.

Miscellaneous.

◆

EFFECT OF ELECTRIC CURRENTS ON THE HUMAN BODY.

At the recent meeting of the British Association, Messrs. H. Newman Lawrence, M.I.E.E., and Arthur Harries, M.D., gave an account of some experiments made with dynamo-generated currents, both continuous and alternating, and with the skin of the subjects in its normal, unmoistened state.

Resistance was measured by connecting two or more persons to a dynamo circuit at an E.M.F. of about 100 volts, noting the current strength passed, and then calculating therefrom the resultant resistance of each person. The Tables given show an average resistance to continuous current of 6,185 ohms, and to alternating current of 4,008 ohms—*i.e.*, about 1·5 higher for continuous current than for alternating. Experiments made regarding contact-area showed that it is an important factor "in determining the seriousness or otherwise of accidents in light and power circuits."

Sensation was tested by passing currents from the same dynamos, using resistance-coils to reduce the current to a convenient level. Two distinct points of comparison were taken, one called "Discomfort Point," and the other "Fixation Point." The tabulated results showed that discomfort point was reached with an average of 18·7 milliampères of continuous current, and with 3·9 milliampères of alternating current. This indicates that sensation to alternating current is 4·7 times greater than it is to continuous current.

With continuous current, "in each instance burning sensation under the electrodes became unbearable after about thirty seconds; this was the only objectionable feature, though electrolytic action was sufficiently marked to induce slight blistering in two of the cases."

With alternating currents a tingling sensation was felt, rapidly increasing to muscular contraction, becoming more and more unpleasant, and accompanied by a feeling of heat in the neighbourhood of the electrodes, though not immediately under the site of contact, as in the case of the continuous current.

The average fixation point to alternating current was 7·5 milliampères; but no such point could be found with the continuous current, thus emphasising this important difference between the two forms of current as regards danger likely to result from accidental contact.

Initial shock is defined as that in which the time-period of contact was a minimum. Many subjects were tested, who one and all considered the initial shock of continuous current to be far less unpleasant than that of alternating current when equal current-strength was used; but "this, from the nature of the experiment, can only be tested with small currents, and it is conceivable that with larger currents such marked differences may not be observable."

In continued contact with the continuous current "we have no muscular fixation, and the subject of the accident would be able to release himself." On the other hand, with alternating current "the subject would be absolutely fixed *in situ* until released by extraneous aid, being exposed the whole time to the full effect of the current passing."

In drawing the following conclusions, the authors say:—"We desire to call attention to the fact that they are based upon certain conditions, and, while we believe them to be sufficiently accurate and reliable under these conditions, we in no sense claim them as true under all conditions.

"(*a*.) That when the human body, with the skin in its normal, unmoistened condition, comes into contact for an appreciable time, with bare-metal conductors of a dynamo-generated continuous current passing at about 100 volts, in such a way that the current passes from hand to hand, and the total contact-area is about 90 square centimetres:—

"1. A current of about 0·016 ampère will pass through it.

"2. That this current can be borne without discomfort for fifteen to thirty seconds.

"3. That after thirty seconds unpleasant burning sensations become marked, and quickly increase.

"4. That the subject is perfectly able to release himself at will during any portion of the time of contact.

"(*b*.) That when the human body comes into contact with dynamo-generated alternating currents, alternating at about sixty to seventy per second, under the same conditions as above:—

"1. A current of about 0·025 ampère will pass through it.

"2. That this current is six times greater than that which produces discomfort.

"3. That instantly the subject is fixed by violent muscular contraction, and suffers great pain.

"4. That the subject is utterly unable to release himself, but remains exposed to the full rigour of the whole current that may be passing.

"(*c*.) That when circuit from electric light or power conductors is accidentally completed through the human body, the danger of serious consequences is many times greater when alternating than when continuous currents are passing at equal voltage; and this is still, to a large extent, true if the voltage of the continuous current be double that of the alternating.

"(*d*.) That with both forms of current a reduction of contact-area materially reduces the amount of current-strength that passes.

"That with the alternating current, if the rate of alternation be reduced below fifty per second, the sensations of pain accompanying muscular fixation will be increased; while, if the rate of alternation be increased, the pain will be diminished."

Notes on Books.

Red-hot Furnace Crown Experiments. Manchester Steam Users' Association, Manchester, 1889.

This is a report on a series of experiments made with a view of ascertaining the result of injecting feed-water into a boiler when the boiler is short of water, and the furnace is red-hot. It has for long been a common belief among engineers that many boiler explosions are due to this cause, and to the same cause has been attributed accidents to domestic circulating boilers which have been allowed to run dry, and have then had cold feed-water admitted. The correctness of this belief has, however, for some time been doubted, and the elaborate series of experiments recorded in this report go to prove that it is altogether erroneous. A Lancashire boiler, 27 feet long, was fitted up for the purpose of the experiments, so that the condition which it was desired to investigate could be reproduced, while observations could be taken of what was going on within the boiler. These experiments were by no means free from danger, and an observatory had to be constructed near the boiler. As a result, it was found that the sudden injection of the cold feed did not cause a rapid generation of steam, and a sudden violent pressure which the boiler in its weakened condition could not stand. In some cases, indeed, the pressure was slightly raised, but it always fell immediately afterwards, and in some cases the cold feed at once lowered the pressure. The writers of the report even think that it might be advantageous in cases where the water has been allowed to get very low, and the furnace crowns to become heated, to turn on the feed, though they hesitate, in the present state of knowledge on the subject, to recommend such a proceeding.

Obituary.

Victor Kullberg.—Mr. Kullberg, who had been a member of the Society of Arts since 1862, has lately died. He was well known as a marine chronometer maker, being admittedly at the head of that business in England. He was born in Gothland, Sweden, in 1824. Coming to London in 1851 for the Great Exhibition, he remained here, and soon started business on his own account. He made many valuable improvements in watches and chronometers, his instruments being constantly the best reported on in the annual Greenwich trials.

General Notes.

Iron in the United States.—The production of pig iron during the year ended June 30th, 1890, was the largest in the history of the iron industry of the United States, amounting to 9,579,779 tons of 2,000 lb., as compared with 3,781,021 tons produced during the census year 1880, and 2,052,821 tons during the census year 1870. From 1870 to 1880 the increase in production amounted to 1,728,200 tons, or nearly 85 per cent., while from 1880 to 1890 the increase was 5,798,758 tons, or over 153 per cent.

Electric Light in the Suez Canal.—The regulations for the use of the electric light came into operation in March, 1887, and during the remainder of that year (according to statistics given in the recent British consular report from Port Said) the number using it was 394. In 1888 the number rose to 1,611, and last year reached 2,445. The average time of transit has also been considerably shortened. In 1886, it was 36 hours; in 1887, 33 hours 58 minutes; in 1888, 31 hours 15 minutes; and in 1889 it had been reduced to 25 hours 50 minutes. The average time for using the electric light in 1889 was 22½ hours. The shortest time taken by a steamer in the transit of the canal in 1889 was 14¾ hours, which is ten minutes less than the fastest passage on record previously.

Silk Production in 1889.—The *Bulletin des Soies et des Soieries* contains statistics compiled by the Lyons syndicate of silk merchants respecting the production of silk in the world last year. The figures are, of course, merely approximate, for the results of the harvest in the interior of China, Japan, India, Persia, and the Caucasus cannot be absolutely estimated. If it were possible to get the exact figures of the production in these comparatively unknown regions, it is not an exaggeration to say that the general silk production of the world would be found to be double what the figures show it to be now. The syndicate has no interest in securing definite information concerning these remote districts. It is sufficient for commercial purposes to obtain the returns of the European harvests, and those districts of the Far East which supply European and American manufacturers. The syndicate estimates the genera production of silk, in 1889, at 11,706,000 kilos. For the previous four years the figures were as follows:—1888, 11,548,000 kilos.; 1887, 11,888,000 kilos; 1886, 10,554,000 kilos; and 1885, 9,002,000 kilos. The average of the four years, 1885 to 1888, being 10,748,000 kilos., it will be seen that the production of 1889 considerably exceeds the average. This result has been obtained notwithstanding the deficiency in the European harvests, owing to the improvement in the Levant district, notably Syria, and especially in the larger Asiatic arrivals.—*The Times.*

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Proceedings of the Society.

CANTOR LECTURES.

THE ELECTROMAGNET.

By Professor Silvanus P. Thompson,
D.Sc., B.A., M.I.E.E.

Lecture IV.—Delivered February 10*th*, 1890.

ELECTROMAGNETIC MECHANISM.

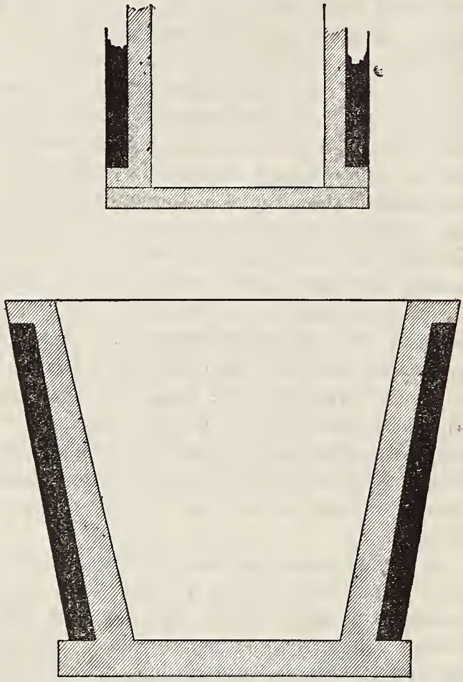
The task before me to-night comprises the following matters:—First, to speak of that particular variety of the electromagnet in which the iron core, instead of being attached to the coils, is movable, and is attracted into them. Secondly, to speak of the modes of equalizing the pull of electromagnets of various sorts over their range of action. Thirdly, to describe sundry mechanisms which depend on electromagnets. Lastly, to discuss the modes of prevention or diminution of the sparking which is so almost invariably found to accompany the break of circuit when one is using an electromagnet.

The Coil-and-Plunger.

First, then, let me deal with the apparatus wherein an iron core is attracted into a tubular coil or solenoid, an apparatus which, for the sake of brevity, I take the liberty of naming as the *coil-and-plunger*. Now, from quite early times, from 1822 at any rate, it was known that a coil would attract a piece of iron into it, and that this action resembled somewhat the action of a piston going into a cylinder—resembled it, I mean to say, in possessing an extended range of action. The use of such a device as the coil-and-plunger was even patented in this country in 1846 under the name of "a new electromagnet." Electromagnetic engines, or motors, were made on this plan by Page, and afterwards by others, and it became generally known as a distinct device. But even now, if you inquire into the literature of the text-books to know what are the peculiar properties of the coil-and-plunger arrangement, you will find that the books give you next to no information. They are content to deal with the thing in very general terms by saying: here is a sort of sucking magnet; the core is attracted in. Some books go so far as to tell you that the pull is greatest when the core is about half way in, a statement which is true in one particular case, but false in a great many others. Another book tells you that the pull is greatest at a point one centimetre below the centre of the coil, for plungers of all different lengths—which is quite untrue. Another book tells you that a wide coil pulls less powerfully than a narrow one, a statement which is true for some cases and not for others. The books also give you some approximate rules, which, however, are very little to the point. The reason why this ought to receive much more careful consideration is because in this mechanism of coil-and-plunger we have a real means not only of equalizing, but also of vastly extending the range of the pull of the electromagnet. Let us take a very simple example for the sake of contrasting the range of action of the ordinary electromagnet with the range of action of the coil-and-plunger.

Here are some numbers which are given in a paper with which I have long been familiar, a paper read by the late Mr. Robert Hunt in 1856 before the Institution of Civil Engineers, and discussed, with that eminent engineer, Robert Stephenson, in the chair. Mr. Hunt described the various types of motors, and spoke of this question of the range of action. He recounted some experiments of his own in which the following was the range of action. There was a horse-shoe electromagnet which at distance zero—that is, when its armature was in contact—pulled with a pull of 220 lbs.; when the distance was made only $\frac{4}{1000}$th of an inch (4 mils), the pull fell to 90; and when the distance was increased to 20 mils (1-50th of an inch), the pull fell to only 36 lbs. The difference from 220 to 36 was within a range of 1-50th of an inch. He contrasts this with the results given by another mechanism, not quite the simple coil-and-plunger, but a variety of electromagnet brought out about the year 1845 by a Dane living in Liverpool named Hjörth, wherein a sort of hollow truncated cone of iron (Fig. 57), with coils wound upon it—a hollow electromagnet, in fact—was caused to act on another electromagnet, one being caused to plunge into the other. Now we have no information what the pull was at distance zero with this curious arrangement of Hjörth's, but at a distance of 1 inch the pull (with a very much larger apparatus than Hunt's) was 160 lbs., the pull at 3 inches was 88 lbs., at 5 inches 72 lbs. Here, then, we have a range of action going not over 1-50th of an inch, but over 5 inches, and falling not from 220 to 36, but from 160 to 72, obviously a much more equable kind of range. At the Institution of Civil Engineers on that occasion, a number of the most celebrated men, Joule, Cowper, Sir William Thomson, Mr. Justice Grove, and Professor Tyndall discussed these matters — discussed them up and down — from the point of view of range of action, and from the point of view of the fact that there was no means of working them at that time except by the consumption of zinc in a primary battery; and they all came to the conclusion that electric motors would never pay. Robert Stephenson summed up the debate at the end in the following words:—"In closing the discussion," he remarked, "there could be no doubt from what had been said that the application of voltaic electricity, in whatever shape it might be developed, was entirely out of the question commercially speaking. Without, however, considering the subject in that point of view, the mechanical applications seemed to involve almost insuperable difficulties. The power exhibited by electromagnetism, though very great, extended through so small a space as to be practically useless. *A powerful magnet might be compared, for the sake of illustration, to a steam-engine with an enormous piston, but with an exceedingly short stroke; such an arrangement was well known to be very undesirable.*"

Fig. 57.



Hjörth's Electromagnetic Mechanism.

Well, from the discussion in 1856—when this question of the length of range was so distinctly set forth—down to the present, there have been a large number of attempts to ascertain exactly how to design a long range electromagnet, and those who have succeeded have, as a general rule, not been the theorists; rather they have been men compelled by force of circumstances to arrive at their result by some kind of—shall we call it—"designing eye," by having a sort of intuitive perception of what was wanted, and going about it in some rough and ready way of their own. Indeed, I am afraid had they tried to get much light from calculations based on orthodox notions respecting the surface distribution of magnetism, and all that kind of thing, they would not have been much helped. There is our old friend, the law of inverse squares, which would of course turn up the first thing, and they would be told that it would be impossible to have a magnet that pulled equally through any range, because the pull was certain to vary inversely according to the square of the distance. I notice that, in a report of my second lecture in one of the London journals, I am announced to have said that the law of inverse squares did not apply to electric forces. I beg to remark that I have said no such thing. It is well to be precise as to what one does say. There has been a lively discussion going on quite lately whether sound varies as the square of the distance—or rather, whether the intensity of it does—and the people who dispute on both sides of the case do not seem to know what the law of inverse squares means. I have also seen the statement made last week in the columns of *The Times*, by one who is supposed to be an eminent authority on eyesight, that the intensity of the colour of a scarlet geranium varies inversely with the square of the distance from which you see it. More utter nonsense was never written. The fact is, the law of inverse squares, which is a perfectly true mathematical law, is true not only for electricity but for light, for sound, and for everything else, provided it is applied to the one case to which a law of inverse squares is applicable. That law is a law expressing the way in which action at a distance falls off when the thing from which the action is proceeding is so small compared with the distance in question that it may be regarded as *a point*. The law of inverse squares is the law universal of action proceeding from a point. The music of an orchestra at 10 feet distance is not four times as loud as at 20 feet distance; for the size of an orchestra cannot be regarded as a mere point in comparison with these distances. If you can conceive of an object giving out a sound, and the object being so small, in relation to the distance at which you are away from it, that it is a point, the law of inverse squares is all right for that, not for the intensity of your hearing, but for the intensity of that to which your sensation is directed. In no case, however, are sensations absolutely proportional to their causes. When the magnetic action proceeds from something so small that it may be regarded as a point compared with the distance, then the law of inverse squares is necessarily and mathematically true.

You may remember that I produced an apparatus (Fig. 27, p. 901) which I said was the only apparatus hitherto devised which did directly prove experimentally the law of inverse squares for the case of a magnetic pole. There was in it a pole, virtually a point at a considerable distance from a small magnetic needle, which was also virtually a point.

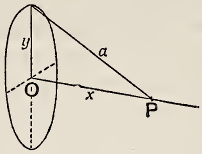
The law of inverse squares is true; but it is not what one works with when one deals with electromagnets having ends of a visible size, acting on armatures themselves of visible sizes, and quite close to them. If you take a case which never occurs in practice, an armature of hard steel, permanently magnetized, so far away from an electromagnet (or rather from one pole only) that the distance between the one pole and the armature on which you are acting is so very great compared with each of them, that each of them may be regarded by comparison as a point, then the law of inverse squares may be rightly applied, but not unless.

Now we want to arrive at a true law. We want to know exactly what the law of action of the coil-and-plunger is. It is not a very difficult thing to work out, provided you get hold of the right ideas. We must begin with a simple case, that of a short coil consisting of but one turn, acting on a single point-pole. From this we may proceed to consider the effect on a point-pole of a long tube of coil. Then we may go on to a more complex case of the tube coil acting on a very long iron core; and last of all from the very long iron core we may pass to the case of a short core.

You all know how a long tube of coil such as this will act on an iron core. Let us make an experiment with it. I turn on the current so that it circulates around the coil along the tube, and when I hold in front of the aperture of the tube this rod of soft iron, it is sucked into the coil. When I pull it out a little way it runs back, as with a spring. The current happens to be a strong one—about 25 amperes; there are about 700 turns of wire on the coil. The rod is about 1 inch in diameter and 20 inches long. So great is the pull that I cannot pull it entirely out. The pull was very small when the rod was outside, but as soon as it gets in it is pulled actively, runs in, and settles down with the ends equally protruding. The tubular coil I have been using is about 14 inches long; but now let us consider a shorter coil. Here is one here only half-an-inch from one end to the other, but I have one somewhere still shorter, so short that the length, parallel to the axis, is very small compared with the diameter of the aperture within. The wire on it consists of but one single turn. Taking such a coil, treating it as only one single ring, with the current going once round, in what way does it act on a magnet that is placed on the axis? First of all, take the case of a very long, permanently magnetised steel magnet, so long, indeed, that any action on the more distant pole is so feeble that it may be disregarded altogether, and only one pole, say the north pole, is near the coil. In what way will that single turn of coil act on that single pole? This is the rule, that the pull does not vary inversely as the square of the distance, nor as any power at all of the distance measured straight along the axis, but inversely as the cube of the slant distance. Let the point O in Fig. 58 (p. 952) represent the centre of the ring, its radius being y. The line O P is the axis of the ring, and the distance from

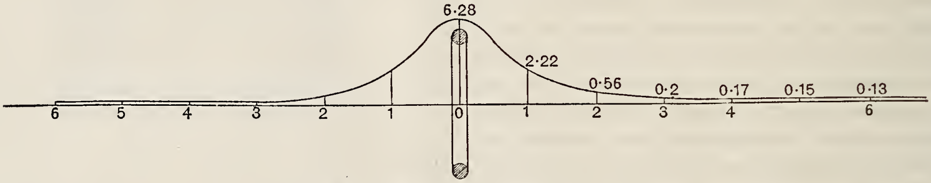
O to P we will call x. The slant distance from P to the ring we call a. Then the pull on the axis towards the centre of this coil varies inversely as the cube of a. That law can be plotted out in a curve for the sake of observing the variations of pull at various points along the axis. Allow me to draw your attention to Fig. 59, which represents a section or edge view of the coil. At various distances right and left of the coil are plotted out vertically the corresponding force, the calculations being made for a current of 10 amperes, circulating once around a ring of 1 centimetre radius. The force with which such a current acts on a magnetic pole of unit strength placed at the central point is 6·28 dynes. If the pole is moved away down the axis, the pull is diminished; at a distance away equal in length to the radius it has fallen to 2·22 dynes. At a distance equal to twice the radius, or 1 diameter, it is only 0·56 dynes, less than one-tenth of what it was at the centre. At 2 diameters it has fallen to 0·17 dyne, or less than 3 per cent.; and the force at 3 diameters is only about 2 per cent. of that at the centre.

Fig. 58.



Action of Single Coil on Point-pole on Axis.

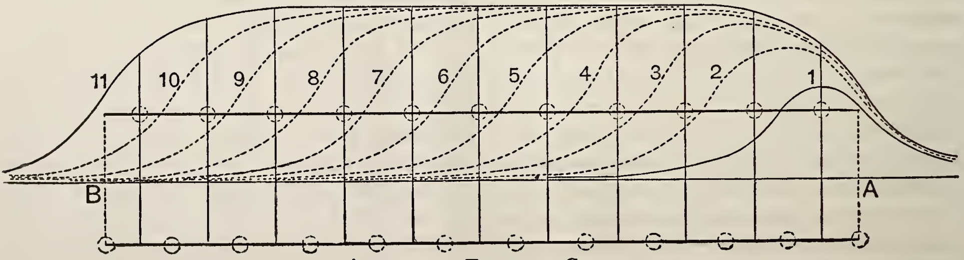
Fig. 59.



Action along Axis of Single Coil.

If, then, we could take a *very* long magnet, we may utterly neglect the action on the distant pole. If I had a long steel magnet with the south pole 5 or 6 feet away, and the north pole at a point 3 diameters (*i.e.*, 6 centimetres in this case) distant from the mouth of the coil, then the pull of the current in one spiral on the north pole 3 diameters away would be practically negligible; it would be less than 2 per cent. of what the pull would be of that single coil when the pole was pushed right up into it. But now, in the case of the tubular coil, consisting of at least a whole layer of turns of wire, the action of all of the turns has to be considered. If the nearest of the turns of wire is at a distance equal to three diameters, all the other turns of wire will be at greater distances, and, therefore, if we may neglect such small quantities as 2 per cent. of the whole amount, we may neglect their action also, for it will be still smaller in amount. Now, for the purpose of arriving at the action of a whole tube of coil, I will adopt a method of plotting devised by Mr. Sayers. Suppose we had a whole tube coiled with copper wire from end to end, its action would be practically the same as though the copper wire were gathered together in small numbers at distant intervals. If, for example, I count the number of turns in a centimetre length of the actual tubular coil which I used in my first experiment, I find there are four. Now if, instead of having four wires distributed over the centimetre, I had one stout wire in the middle of that space to carry four times the current, the general effect would be the same. This diagram (Fig 60) is calculated out on the supposition that the

Fig. 60.



Action of Tubular Coil.

effect will be not greatly different if the wires were aggregated in that way, and it is easier to calculate. If, beginning at the end of the tube marked A, we take the wires over the first centimetre of length and aggregate them, we can draw a curve, marked 1, for the effect of that lot of wires. For the next lot, we could draw a similar curve, but instead of drawing it on the horizontal line we will add the several heights of the second curve on to those of the first, and that gives the curve marked 2; for the third part, add the ordinates of another similar curve, and so gradually build up a final curve for the total action of this tubular coil on a unit pole at different points along the axis. This resultant curve begins about 2½ diameters away from the end, rises gently, and then suddenly, and then turns over and becomes nearly flat with a long level back. It does not rise any more after a point about 2½ diameters along from A; the curve at that point becomes practically flat, or does not vary more than about 1 per cent., however long the tube may be. For example, in a tubular coil 1 inch in diameter and 20 inches long, there will be a uniform magnetic field for about 15 inches along the middle of the coil. In a tubular coil 3 centimetres in diameter and 40 centimetres long, there will be a uniform magnetic field for about 32 centimetres along the middle of the coil. The meaning of this is that the value of the magnetic forces down the axis of that coil begins outside the mouth of the tube, increases, rises to a certain maximum amount a little within the mouth of the tube, and after that is perfectly constant nearly all the way along the tube, and then falls off symmetrically as you get to the other end. The ordinates drawn to the curve represent the forces at corresponding points along the axis of the tube, and may be taken to represent not simply the magnetizing force, but the pull on a magnetic pole at the end of an indefinitely long, thin steel magnet of fixed strength.

The rule for calculating the intensity of the magnetic force at any point on the axis of the long tubular coil within this region where the force is uniform, is:—

$$H = \frac{4}{10}\pi \times \text{the ampere-turns per cm. of length.}$$

And, as the total magnetizing power of a tubular coil is proportional not only to the intensity of the magnetic force at any point, but also to the length, the integral magnetizing effect on a piece of iron that is inserted into the coil may be taken as practically equal to $\frac{4}{10}\pi \times$ the total number of ampere-turns in that portion of the tubular coil which surrounds the iron. If the iron protrudes as much as 3 diameters at both ends, the total magnetizing force is simply $\frac{4}{10}\pi \times$ the whole number of ampere-turns.

Now that case is of course not the one we are usually dealing with. We cannot procure steel magnets with unalterable poles of fixed strength. Even the hardest steel magnet, magnetized so as to give us a permanent pole near or at the end of it—quite close up to the end of it when you put it into a magnetizing coil—becomes by that fact further magnetized. Its pole becomes strengthened as it is drawn in, so that the case of an unalterable pole is not one which can actually be realised. One does not usually work with steel; one works with soft-iron plungers which are not magnetized at all when at a distance away, but become magnetized in the act of being placed at the mouth of the coil, and which become more highly magnetized the further they go in. They tend, indeed, to settle down, with the ends protruding equally, for that is the position where they most nearly complete the magnetic circuit; where, therefore, they are most completely and highly magnetized. Accordingly, we have this fact to deal with, that whatever may be the magnetizing forces all along a tube, the magnetism of the entering core will increase as it goes on. We must therefore have recourse to the following procedure. We will construct a curve in which we will plot not simply the magnetizing forces of the spiral at different points, but the product of the magnetizing forces into the magnetism of the core which itself increases as the core moves in. The curve with a flat top to it corresponds to an ideal case of a single pole of constant strength. We wish to pass from this to a curve which shall represent a real case, with an iron core. Let us still suppose that we are using a very long core, one so long that when the front pole has entered the coil the other end is still a long way off. With an iron core of course it depends on the size and quality of the iron as to how much magnetism you get for a given amount of magnetizing power. When the core has entered up to a certain point, you have all the magnetizing forces up to that point acting on it: it acquires a certain amount of magnetism, so that the pull will necessarily go on increasing, and increasing although the intensity of the magnetic force from point to point along the axis of the coil remains the same, until within about two diameters from the far end. Although the magnetic force inside the long spiral remains the same, because the magnetism of the core is increasing, the pull goes on increasing and increasing (if the iron does not get saturated) at an almost uniform rate all the way up until the piece of iron has been poked pretty nearly through to the distant end. In Fig. 61, a tubular coil, B A, is represented. Suppose a long iron core is placed on the axis to the right, and that its end is gradually brought up toward B. When it arrives at X, the pull becomes sensible, and increases at first rapidly, as the core enters the mouth of the tube, then gently, as the core travels along, attaining a maximum, C, about at the further end, A, of the tube. When it approaches to the other end, A, it comes to the region where the magnetizing force falls off, but the magnetism is still going on increasing, because something is still being added to the total magnetizing power, and these two effects nearly balance one another, so that the pull arrives at the maximum. This is the highest point, C, on the curve; the greatest pull occurring just as the end of the iron core arrives at the bottom or far end of the tubular coil; from which point there is a very rapid falling off. The question of rapidity of descent from that point depends only on how long the core is. If the core is a very long one, so that its other pole is still very far away, you have a long, slow descent going on over some three diameters, and gradually vanishing. If, however, the other pole is coming up within measureable distance of B, then the curve will come down more rapidly to a definite point, X_1. To take a simple case where the iron core is twice as long as the coil, its curve will descend in pretty nearly a straight line down to a point such that the ends of the iron rod stand out equally from the ends of the tube.

Fig. 61.

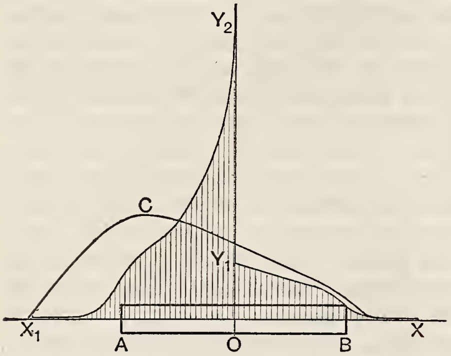


Diagram of Force and Work of Coil-and-Plunger.

Precisely similar effects will occur in all other cases where the plunger is considerably longer than (at least twice as long as) the coil surrounding it. If you take a different case, however, you will get another effect. Take the case of a plunger of the same length as the coil, then this is what necessrily happens. At first the effects are much the same; but as soon as the core has entered about half, or a little more than half its length, you begin to have the action of the other pole that is left protruding outside tending to pull the plunger back; and although the magnetizing force goes on increasing the further the plunger enters, the repulsion exerted by the coil on the other pole of the plunger keeps increasing still faster as this end nears the mouth of the coil. In that case the maximum will occur at a point a little further than half way along the coil, and from that point the curve will descend and go to zero at A; that is to say, there will be no pull when both ends of the plunger coincide with the two ends of the coil. If you take a plunger that is a little shorter than the coil, then you find that the attraction comes down to zero at an earlier period still. The maximum pull occurs earlier, and so does the reduction of the pull to zero; there being no action at all upon the short core when it lies wholly within that region of the tube within which the intensity of the magnetic force is uniform. That is to say, for any portion of this tube corresponding to the flat top of the curve of Fig. 60 (p. 952), if the plunger of iron is so short as to lie wholly within that region, then there is no action upon it; it is not pulled either way. Now these things can be not only predicted by the help of such a law as that, but verified by experiment. Here is a set of tubular coils which we use at the Finsbury Technical College for the purpose of verifying these laws. There is one here about 9 inches long, one about half that length, another just a quarter. They are all made alike in this way, that they have exactly the same weight of copper wire, cut from the same hank, upon them. There are, of course, more turns on the long one than on the shorter, because with the shorter ones each turn requires on the average a larger amount of wire, and therefore the same weight of wire will not make the same number of windings. We use that very simple apparatus, a Salter's balance, to measure the pull exerted down to different distances on cores of various lengths. You find in every case the pull increases and becomes a maximum, then diminishes. We will now make the experiment, taking first a long plunger, roughly about twice as long as the coil. The pull increases as the plunger goes down, and the maximum pull occurs just when the lower end gets to the bottom; beyond that the pull is less. Using the same plunger, with these shorter coils, one finds the same thing, in fact more marked, for we have now a core which is more than twice the length of the coil. So we find, taking in all these cases, that the maximum pull occurs, not when the plunger is half way in, as the books say, but when the bottom end of it is just beginning to come out through the bottom of the coil that we are using. If, however, we take a shorter plunger, the result is different. Here is one just the same length as the coil. With this one the maximum pull does occur when the core is about half way in; the maximum pull is just about at the middle. Again, with a very short core—here is one about one-sixth of the length of the coil—the maximum pull occurs as it is going into the mouth of the coil; and, when both ends have gone in so far that it gets into the region of equable magnetic field there is no more pull on one end than on the other; one end is trying to move with a certain force down the tube, and the other end is trying to move with exactly equal force up the tube, and the two balance one another. If we carry that to a still more extreme case, and employ a little round ball of iron to explore down the tube, you will find this curious result, that the only place where any pull occurs on the ball is just as it is going in at the mouth. For about half an inch in the neck of the coil there is a pull; but there is no pull down the interior of the tube at all, and there is no measurable pull outside.

Now these actions of the coil on the core are capable of being viewed from another standpoint. Every engineer knows that the work done by a force has to be measured by multiplying together the force and the distance through which its point of application moves forward. Here we have a varying force acting over a certain range. We ought, therefore, to take the amount of the force at each point, and multiply that by the adjacent little bit of range, averaging the force over that range, and then take the next value of force with the next little bit of range, and so consider in small portions the work done along the whole length of travel. If we call the length of travel x, the element of length must be called dx. Multiply that by f, the force. The force multiplied by the element of length gives us the work, dw, done in that short range. Now the whole work over the whole travel is made up of the sum of such elements all added together; that is to say, we have to take all the various values of f, multiply each by its own short range dx, and the sum of all those, writing $\int$ for the sum, would be equal to the sum of all the work; that is to say, the whole work done in putting the thing together will be written:—

$$w = \int f\,dx.$$

Now what I want you to think about is this: here, say, is a coil, and there is a distant core. Though there is a current in the coil it is so far away from the core that practically there is no action; bring them nearer and nearer together; presently they begin to act on one another, there is a pull, which increases as the core enters, then comes to a maximum, then dies away as the end of the core begins to protrude at the other side. There is no further pull at all when the two ends stand out equally. Now there has been a certain total amount of work done by this apparatus. Every engineer knows that if we can ascertain the force at every point along the line of travel the work done in that travel is readily expressed by the area of the force-curve. Think of the curve X C X, in Fig. 61, p. 954, the ordinates of which represent the forces. The whole area underneath this curve represents the work done by the system, and therefore represents equally the work you would have to do upon it in pulling the system apart. The area under the curve represents the total work done in attracting in the iron plunger, with a pull distributed over the range $X\,X_1$.

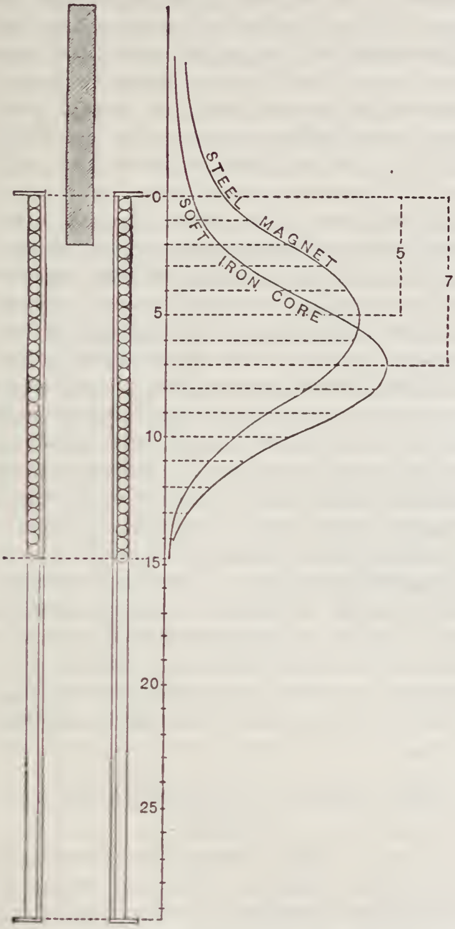
Now I want you to compare that with the case of an electromagnet where, instead of having this distributed pull, you have a much stronger pull over a much shorter range. I have endeavoured to contrast the two in the other curves drawn in Fig. 61. Suppose we have our coil, and suppose the core, instead of being made of one rod such as this, were made in two parts, so that they could be put together with a screw in the middle, or fastened together in any other mechanical way. Now first treat this rod as a single plunger, screw the two parts together, and begin with the operation of allowing it to enter into the coil, the work done will be the area under the curve which we have already considered. Let us divide the iron core into two. First of all put in one end of it; it will be attracted up in a precisely similar fashion, only being a shorter bar, the maximum would be a little displaced. Let it be drawn in up to half way only; we have now a tube half filled with iron, and in doing so we shall have had a certain amount of work done by the apparatus. As the piece of iron is shorter, the force-curve, which ascends from X to Y_1, will lie little lower than the curve, XCX_1; but the area under that lower curve, which stops half way, will be the work done by the attraction of this half core. Now go to the other end and put in the other half of the iron. You now have not only the attraction of the tube, but that of the piece which is already in place, acting like an electromagnet. Beginning with a gentle attraction, it soon runs up, and draws the force-curve to a tremendously steep peak, becoming a very great force when the distance asunder is very small. We have therefore in this case a totally different curve made up of two parts, a part for the putting in of the first half of the core, and a steeper part for the second; but the net result is, we have the same quantity of iron magnetized in exactly the same manner by the same quantity of electric current running round the same amount of copper wire—that is to say, the total amount of work done in these two cases is necessarily equal. Whether you allow the entire plunger to come in by a gentle pull over a long range, or whether you put the core in in two pieces—one part with a gentle pull, and the other with a sudden spring up at the end—the total work must be the same; that is to say, the total area under our two new curves must be the same as the area under the old curve. The advantage, then, of this coil-and-plunger method of employing iron and copper is, not that it gets any more work out of the same expenditure of energy, but that it distributes the pull over a considerable range. It does not, however, equalize it altogether over the range of travel.

A number of experimental researches have been made from time to time to elucidate the working of the coil-and-plunger. Hankel, in 1850, examined the relation between the pull in a given portion of the plunger and the exciting power. He found that, so long as the iron core was so thick and the exciting power so small that magnetization of the iron never approached saturation, the pull was proportional to the square of the current, and was also proportional to the square of the number of turns of wire. Putting these two facts together we get the rule—which is true only for an unsaturated core in a given position—that the pull is proportional to the square of the ampere-turns. This might have been expected, for the magnetism of the iron core will, under the assumptions made above, be proportional to the ampere-turns, and the intensity of the magnetic field in which it is placed being also proportional to the ampere-turns, the pull, which is the product of the magnetism and of the intensity of the field, ought to be proportional to the square of the ampere-turns.

Dub, who examined cores of different thicknesses, found the attraction to vary as the square root of the diameter of the core. His own experiments show that this is inexact, and that the force is quite as nearly proportional to the diameter as to its square root. There is again reason for this. The magnetic circuit consists largely of air-paths by which the magnetic lines flow from one end to the other. As the main part of the magnetic reluctance of the circuit is that of the air, anything which reduces the air reluctance increases the magnetization, and, consequently, the pull. Now, in this case, the reluctance of the air-paths is mainly governed by the surface exposed by the end portions of the iron core. Increasing these diminishes the reluctance, and increases the magnetization by a corresponding amount. Von Waltenhofen, in 1870, compared the attraction exerted by two equal (short) tubular coils on two iron cores, one of which was a solid cylindrical rod, and the other a tube of equal length and weight, and found the tube to be more powerfully attracted. Doubtless, the effect of the increased surface in diminishing the reluctance of the magnetic circuit explains the cause of the observation.

Von Feilitzsch compared the action of a tubular coil upon a plunger of soft iron with that exerted by the same coil upon a core of hard magnetized steel of equal dimensions. The plungers (Fig. 62, p. 957) were each 10·1 centimetres long; the coil being 29·5 centimetres in length, and 4·2 in diameter. The steel magnet showed a maximum attraction when it had plunged to a depth of 5 centimetres, whilst the iron core had its maximum at a depth of 7 centimetres, doubtless because its own magnetization went on increasing more than did that of the steel core. As the uniform field region began at a depth of about 8 centimetres, and the cores were 10·1 centimetres in length, one would expect the attracting force to come to zero when the cores had plunged into a depth of about 18 centimetres. As a matter of fact, the zero point was reached a little earlier. It will be noticed that the pull at the maximum was a little greater in the case of the iron plunger.

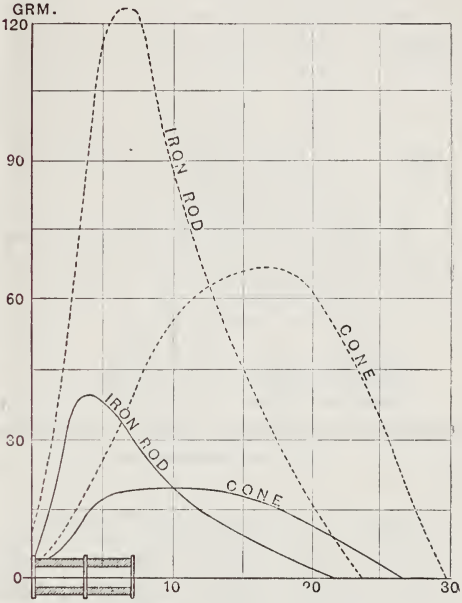
Fig. 62.



Von Feilitzsch's Experiment on Plungers of Iron and Steel

The most careful researches of late years are those made by Dr. Theodore Bruger, in 1886. One of his researches, in which a cylindrical iron plunger was used, is represented by two of the curves in Fig. 63. He used two coils, one 3½ centimetres long, the other 7 centimetres long. These are indicated in the bottom left-hand corner. The exciting current was a little over 8 amperes. The cylindrical plunger was 39 centimetres long. The plunger is supposed, in the diagram, to enter on the left, and the number of grammes of pull is plotted out opposite the position of the entering end of the plunger. As the two curves show by their steep peaks, the maximum pull occurs just when the end of the plunger begins to emerge through the coil; and the pull comes down to zero when the ends of the core protrude equally. In this Figure the dotted curves relate to the use of the longer of the two coils. The height of the peak, with the coil of double length, is nearly four times as great, there being double ampere-turns of excitation. In some other experiments, which are plotted in Fig. 64, (p. 958), the same core was used with a tubular coil 13 centimetres long. Using currents of various strengths, 1·5 ampere, 3, 4·8, 6, or 8 amperes, the pull is of course different, but, broadly, you get the same effect, that the maximum pull occurs just where the pole begins to come out at the far end of the tubular coil. There are slight differences; with the smallest amount of current the maximum is exactly over the end of the tube, but with currents rather larger, the maximum point comes a little farther back. When the core gets well saturated, the force curve does not go on rising so far; it begins to turn over at an earlier stage, and the maximum place is

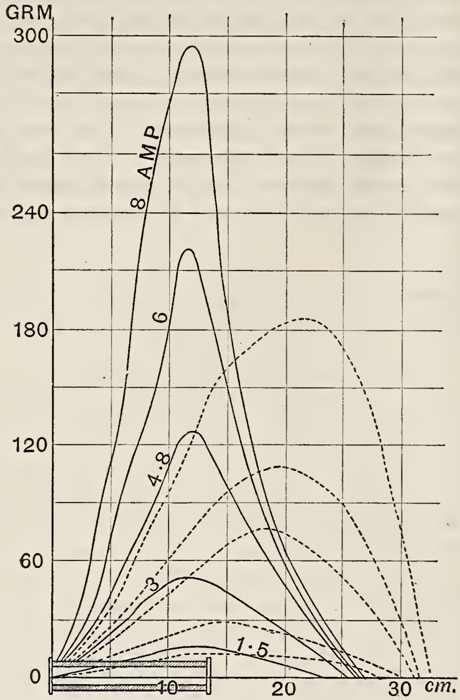
Fig. 63.



Bruger's Experiments on Coils and Plungers.

necessarily displaced a little way back from the end of the tube. That was also observed by Von Waltenhofen when using the steel magnet.

FIG. 64.



BRUGER'S EXPERIMENTS, USING CURRENTS OF VARIOUS STRENGTH.

EFFECT OF USING CONED PLUNGERS.

But now if, instead of employing a cylindrical core, you employ one that is pointed, you find this completely alters the position of the maximum pull, for now the point is insufficient to carry the whole of the magnetic lines which are formed in the iron rod. They do not come out at the point, but filter through, so to speak, along the sides of the core. The region where the magnetic lines come up through the iron into the air is no longer a definite "pole" at or near the end of the rod, but is distributed over a considerable surface; consequently when the point begins to poke its nose out, you still have a larger portion of iron up the tube, and the pull, instead of coming to a maximum at that position, is distributed over a wider range. I am now making the experiment roughly with my spring balance and a conical plunger, and I think you will be able to notice a marked difference between this case and that of the cylindrical plunger. The pull increases as the plunger enters, but the maximum is not so well defined with a pointed core as it is with one that is flat-ended. This essential difference between coned plungers and cylindrical ones was discovered by an engineer of the name of Krizik, who applied his discovery in the mechanism of the Pilsen arc lamps. Coned plungers were also examined by Bruger. In Fig. 63 are given the curves that correspond to the use of a coned iron core, as well as those corresponding to the use of the cylindrical iron rod. You will notice that, as compared with the cylindrical plunger, the coned core never gave so big a pull, and the maximum occurred not as the tip emerged, but when it got a very considerable way out on the other side. So it is with both the shorter and the longer coil. The dotted curves in Fig. 64 represent the behaviour of a coned plunger. With the longer coil represented, and with various currents, the maximum pull occurred when the tip had come a considerable way out; and the position of the maximum pull, instead of being brought nearer to the entering end with a high magnetizing current, was actually caused to occur further down; the range of action became extended with large currents as compared with small ones. Bruger also investigated the case of cores of very irregular shapes, resembling, for example, the shank of a screw-driver, and found a very curious and irregular force-curve. There is a good deal more yet to be done, I fancy, in examining this question of distributing the pull on an attracted core by altering the shape of it, but Bruger has shown us the way, and we ought not to find very much difficulty in following him.

OTHER MODES OF EXTENDING RANGE OF ACTION.

Another way of altering the distribution of the pull is to alter the distribution of the wire on the coil. Instead of having a coned core use a coned coil, the winding being heaped up thicker at one end than at the other. Such a coil, wound in steps of increasing thickness, has been used for some years by Gaiffe, in his arc lamp; it has also been patented in Germany by Leupold. M. Trève has made the suggestion to employ an iron wire coil, so to utilise the magnetism of the iron that is carrying the current. Trève declares that such coils possess, for an equal current, four times the pulling power. I doubt whether that is so; but even if it were, we must remember that to drive any given current through an iron wire, instead of a copper wire of the same bulk, implies that we must force the current through six times the resistance; and, therefore, we shall have to employ six times the horse-power to drive the same current through the iron wire coil, so that there is really no gain. Again, a suggestion has been made to enclose in an iron jacket the coil employed in this way. Iron-clad solenoids have been employed from time to time. But they do not increase the range of action. What they do is to tend to prevent the falling off of the internal pull at the region within the mouth of the coil. It equalises the internal pull at the expense of all external action. An iron-clad solenoid has practically no attraction at all on anything outside of it, not even on an iron core placed at a distance of half a diameter of the aperture: it is only when the core is inside the tube that the attraction begins; and the magnetizing power is practically uniform from end to end. Last year I wished to make use of this property for some experiments on the action of magnetism on light, and for that purpose I had built, by Messrs. Paterson and Cooper, this powerful coil, which is provided with a tubular iron jacket outside, and a thick iron disk perforated by a central hole covering each end. The magnetic circuit around the exterior of the coil is practically completed with soft iron. With this coil, one may take it, there is an absolutely uniform magnetic field from one end of the tube to the other; not falling off the at the ends as it would do if the magnetic circuit had simply an air return. The whole of the ampere-turns of exciting power are employed in magnetizing the central space, in which therefore the actions are very powerful and uniform. The coil and its uses were described in my lecture last year at the Royal Institution on "Optical Torque."

MODIFICATIONS OF THE COIL-AND-PLUNGER.

In one variety of the coil-and-plunger mechanism a second coil is wound on the plunger. Hjörth used this modification, and the same thing has been employed in several arc lamps. There is a series of drawings upon this wall depicting the mechanism of about a dozen different forms of arc lamp, all made by Messrs. Paterson and Cooper. In one of these there is a plunger with a coil on it drawn into a tubular coil, the current flowing successively through both coils. In another there are two separate coils in separate circuits, one of thin wire and one of thick, one being connected in series with the arc, and one in shunt.

DIFFERENTIAL COIL-AND-PLUNGER.

There is a third drawing here showing the arrangement, which was originally introduced by Siemens, wherein a plunger is drawn at one end into the coil that is in the main circuit, and at the other end into a coil that is in shunt. That differential arrangement has certain peculiar properties of which I must not now stop to speak in detail. It is obvious that where one core plunges its opposite ends into two coils, the magnetization will depend on both coils, and the resultant pull will not be simply the difference between the pull of the two coils acting each separately. There is, however, another differential arrangement, used in the Brockie-Pell and other arc lamps, in which there are two separate plungers attached to the two ends of a *see-saw* lever. In this case the two magnetizing actions are separate. In a third differential arrangement there is but one plunger and one tubular bobbin, upon which are wound the two coils, differentially, so that the action on the plunger is simply due to the difference between the ampere-turns circulating in the two separate wires.

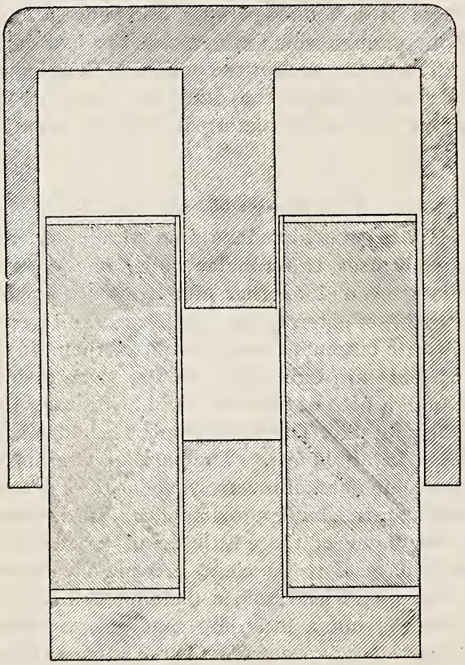
COIL-AND-PLUNGER-COIL.

When one abandons iron altogether, and merely uses two tubular coils, one of wide diameter, and another of narrower diameter, capable of entering into the former, and passes electric currents through both of them, if the currents are circulating in the same fashion through both of them they will be drawing into one another. This arrangement has also been used in arc lamps. The parallel currents attract one another inversely, not as the square of the distance, but approximately as the distance. This is one of those little details about which it is as well to be clear. About once a year some kind friend from a distance writes to me pointing out a little slip that he says occurs in my book on electricity, in the passage where I am speaking about the attraction of parallel wires. I have made the terrible blunder of leaving out the word square; for I say the attraction varies inversely as the distance, and my readers are kind enough to correct me. Now when I wrote that passage I considered carefully what I had to write, and the attraction does not vary inversely as the square of the distance, because two parallel wires do not act on one another as two points. They act as two straight lines or two parallel lines, and the attraction between two parallel lines of current, or two parallel lines of magnetism, or two parallel lines of anything else that can attract, will not act inversely as the square, but simply inversely as the distance in between.

INTERMEDIATE FORMS.

Now this property of the coil-and-plunger of extending the range of action has been adopted in various ways by inventors whose object was to try and make electromagnets with a sort of intermediate range. For certain purposes it is desirable to construct an electromagnet which, while having the powerful pull of the electromagnet, should have over its limited range of action a more equable pull, resembling in this respect the equalizing of range of the coil and plunger. Some of these intermediate forms of apparatus are shown in the following diagrams. Here (Fig. 65) is a peculiar form of electromagnet; it combines some of the features of the iron-clad electromagnet, with those of the moveable plunger; it has a limited range of action, but is of great power over that range, owing to its excellent magnetic circuit. It was invented, in 1870, by Stevens and Hardy, for use in an electric motor for running sewing machines. A very similar form is used in Weston's arc lamp. A form of plunger electromagnet invented by Holroyd Smith in 1877, resembles Fig. 65 inverted; the coil being surrounded by an iron jacket, whilst a plunger, furnished at the top with an iron disk, descends down the central tube to meet the iron at the bottom.

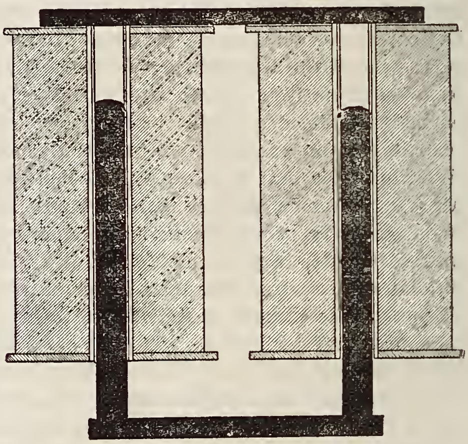
FIG. 65.



PLUNGER ELECTROMAGNET OF STEVENS AND HARDY.

Then there is another variety, of which I was able to show an example last week by the kindness of the Brush Company, namely, the plunger electromagnet employed in the Brush arc lamps. A couple of tubular coils receive each an iron plunger, connected together by a yoke; whilst above, the magnetic circuit is partially completed by the sheet of iron which forms part of the enclosing box. You have here, also, the advantage of a fairly complete magnetic circuit, together with a comparatively long travel of the plunger and coil. It is a fair compromise between the two ways of working. The pull is not, however, in any of these forms, equal all along the whole range of travel; it increases as the magnetic circuit becomes more complete.

FIG. 66.

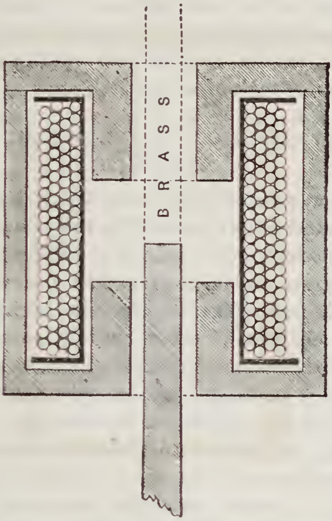


ELECTROMAGNET OF BRUSH ARC LAMP.

There are several other intermediate forms. For example, one inventor, Gaiser, employs a horse-shoe electromagnet, the cores of which protrude a good distance beyond the coils, and for an armature he employs a piece of sheet-iron, bent round so as to make at its ends two tubes, which enclose the poles, and are drawn down over them. Contrast with this design one of much earlier date by an engineer, Roloff, who made his electromagnets with iron cores not standing out, but sunk below the level of the ends of the coils, whilst the armature was furnished with little extensions that passed down into these projecting tubular ends of the coils. Some arc lamps have magnets of precisely that form, with a short plunger entering a tubular coil, and met half-way down by a short fixed core inside the tube.

Here (Fig. 67) is one form of tubular ironclad electromagnet that deserves a little more attention, being the one used by Messrs. Ayrton and Perry in 1882; a coil has an iron jacket round it, and also an annular iron disk across the top, and an annular iron disk across the bottom, there being also a short internal tube of iron extending a little way down from the top, almost meeting another short internal tube of iron coming up from the bottom. The magnetic effect of the enclosed copper coil is concentrated within an extremely short space, between the ends of the internal tubes, where there is a wonderfully strong uniform field. The range of action you can alter just as you please in the construction by shortening or lengthening the internal tubes. An iron rod inserted below is drawn with great power and equality of pull over the range from one end to the other of these internal tubes.

Fig. 67.



Ayrton and Perry's Tubular Ironclad Electromagnet.

Action of Magnetic Field on Small Iron Sphere.

In dealing with the action of tubular coils upon iron cores, I showed how, when a very short core is placed in a uniform magnetic field, it is not drawn in either direction. The most extreme case is where a small sphere of soft iron is employed. Such a sphere, if placed in even the most powerful magnetic field, does not tend to move in any direction if the field is truly uniform. If the field is not uniform, then the iron sphere always tends to move from the place where the field is weak to a place where the field is stronger. A ball of bismuth or one of copper tends, on the contrary, to move from a place where the field is strong to a place where the field is weaker. This is the explanation of the actions called "dia-magnetic," which were at one time erroneously attributed to a supposed diamagnetic polarity opposite in kind to the ordinary magnetic polarity. A simple way of stating the facts is to say that a small sphere of iron tends to move up the *slope* of a magnetic field, with a force proportional to that slope; whilst (in air) a sphere of bismuth or one of copper tends, with a feeble force, to move down that slope. Any small piece of soft iron—a short cylinder, for example—shows the same kind of behaviour as a small sphere. In some of Ayrton and Perry's coiled-ribbon ampere-meters and voltmeters, and in some of Sir William Thomson's current-meters, this principle is applied.

Sectioned Coils, with Plunger.

An important suggestion was made by Page, about 1850, when he designed a form of coil-and-plunger having a travel of indefinitely long range. The coiled tube, instead of consisting merely of one coil, excited simultaneously throughout its whole length by the current, was constructed in a number of separate sections or short tubes, associated together end to end, and furnished with means for turning on the electric current into any of the sections separately. Suppose an iron core to be just entering into any section, the current is turned on in that section, and as the end of the core passes through it, the current is then turned on in the section next ahead. In this way an attraction may be kept up along a tube of indefinite length. Page constructed an electric motor on this plan, which was later revived by Du Moncel, and again by Marcel Deprez in his electric "hammer."

Winding of Tubular Coils and Electromagnets.

The mention of this mode of winding in sections leads me to say a few final words about winding in general. All ordinary coils, whether tubular or provided with fixed cores, are wound in layers of alternate right-handed and left-handed spirals. In a preceding lecture I mentioned the mistaken notion, now disproved, that there is any gain in making all the spirals right-handed or all left-handed. For one particular case there is an advantage in winding a coil in sections; that is to say, in placing partitions or *cloisons* at intervals along the bobbin, and winding the wire so as to fill up each of the successive spaces between the partitions before passing on from one space to the next. The case in which this construction is advantageous is the unusual case of coils that are to be used with currents supplied at very high potentials. For when currents are supplied at very high potentials there is a very great tension* exerted on the insulating material, tending to pierce it with a spark. By winding a coil in *cloisons*, however, there is never so great a difference of potentials between the windings on two adjacent layers as there would be if the layers were wound from end to end of the whole length of coil. Consequently, there is never so great a tension on the insulating material between the layers, and a coil so wound is less likely to be injured by the occurrence of a spark.

Another variety of winding has been suggested, namely, to employ in the coils a wire of graduated thickness. It has been shown by Sir William Thomson to be advantageous in the construction of the coils of galvanometers to use for the inner coils of small diameter a thin wire; then, as the diameter of the windings increase, a thicker wire; the thickest wire being used on the outermost layers; the gauge being thus proportioned to the diameter of the windings. But it by no means follows that the plan of using *graded wire*, which is satisfactory for galvanometer coils, is necessarily good for electromagnets. In designing electromagnets it is necessary to consider the means of getting rid of heat; and it is obvious that the outer layers are those which are in the most favourable position for getting rid of this heat. Experience shows that the under layers of coils of electromagnets always attain a higher temperature than those at the surface. If, therefore, the inner layers were to be wound with finer wire, offering higher resistance, and generating more heat than the outer layers, this tendency to over-heating would be still more accentuated. Indeed, it would seem wise rather to reverse the galvanometer plan, and wind electromagnets with wires that are stouter on the inner layers and finer on the outer layers.

Yet another mode of winding is to employ several wires united in parallel, a separate wire being used for each layer, their anterior extremities being all soldered together at one end of the coil, and their posterior extremities being all soldered together at the other. Magnetically, this mode of winding presents not the slightest advantage over winding with a single stout wire of equivalent section. But it has lately been discovered that this mode of winding with *multiple wire* possesses one incidental advantage, namely that its use diminishes the tendency to sparking which occurs at break of circuit.

EXTENSION OF RANGE BY OBLIQUE APPROACH.

I now pass to the means which have been suggested for extending the range of motion, or of modifying its amount at different parts of the range, so as to equalize the very unequable pull. There are several such devices, some electrical, others purely mechanical, others electro-mechanical. First, there is an electrical method. André proposed that as soon as the armature has begun to move nearer, and comes to the place where it is attracted more strongly, it is automatically to make a contact, which will shunt off part of the current and make the magnetism less powerful. Burnett proposed another means; a number of separate electromagnets acting on one armature, but as the latter approached these electromagnets were one after the other cut out of the circuit. I need not say the advantages of that method are very hypothetical. Then there is another method which has been used many times with very great success, the method of allowing the motion of the armature to occur obliquely, it being mechanically constrained so as to move past, instead of towards the pole. When the armature is pulled thus obliquely, the pull will be distributed over a definite wider range. Here is a little motor made on that very plan. A number of pieces of iron set on the periphery of a wheel are successively attracted up sideways. An automatic device breaks the circuit as every piece of iron comes near, just at the moment when it gets over the poles, and the current being cut off, it flies on beyond and another piece comes up, is also attracted in the same way, and then allowed to pass. A large number of toy motors have been made from time to time on this plan. I believe Wheatstone was the first to devise the method of oblique approach about the year 1841. He made many little electromagnetic motors, the armatures of which were in some cases solid rims of iron arranged as a sort of wheel, with two or more zig-zag internal teeth, offering oblique surfaces to the attraction of an electromagnet. Such little motors are often now used for spinning Geissler's vacuum tubes. In these motors the iron rim is fixed, and the electromagnet rotates. The pole of the electromagnet finds itself a certain distance away from the iron ring, it tries to get nearer. The only way it can get nearer is by swinging round, and so it gradually approaches, and as it approaches the place where it is nearest to the internal projection of the rim the current is cut off, and it swings further. This mode may be likened to a cam in a mechanical movement. It is, in fact, nothing else than an *electromagnetic cam*. There are other devices too, which are more like electromagnetic *linkages*. If you curve the poles or shape them out you may obtain actions which are like that of a wedge on an inclined plane. There is an electromagnet in one of Paterson and Cooper's arc lamps wherein the pole-piece, coming out below the magnet, has a very peculiar shape, and the armature is so pivotted with respect to the magnet, that as the armature approaches the core as a whole, its surface recedes from that of the pole-piece, the effect being that the pull is equalized over a considerable range of motion. There is a somewhat similar device in De Puydt's pattern of arc lamp.

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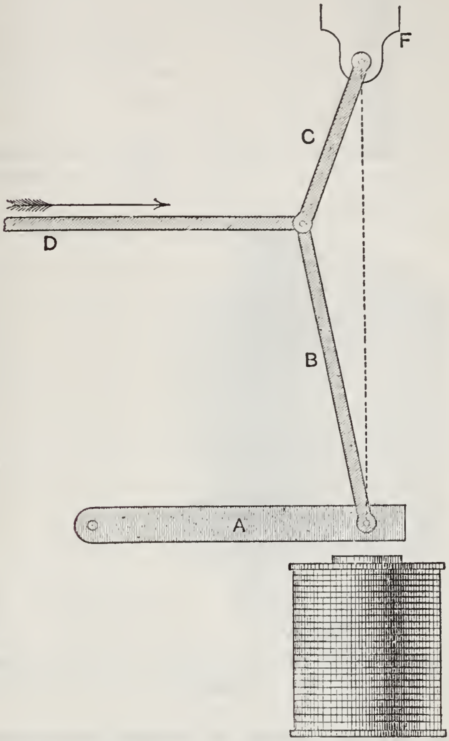
* The tension on the insulating material, tending to pierce it with a spark, is proportional to the square of the difference of potentials (per unit thickness) to which the insulating material is subject. It is incorrect to talk about the tension of the conductor, or about the tension of the current; for the tension or electric stress is always an action affecting the di-electric or insulating material.

Here is another device for oblique approach, made by Froment. In the gap in the circuit of the magnet a sort of iron wedge is put in, which is not attracted squarely to either face, but comes in laterally between guides. Another of Froment's equalizers, or distributors, consists of a parallel motion attachment for the armature, so that oblique approach may take place, withot actual contact. Here, Fig. 68, is another mechanical method of equalizing devised by Froment, and used by Le Roux. You know the Stanhope lever, the object of which is to transform a weak force along a considerable range into a powerful force of short range. Here we use it backwards. The armature itself, which is attracted with a powerful force of short range, is attached to the lower end of the Stanhope lever, and the arm attached to the knee of the lever will deliver a distributed force over quite a different range. One way, not of equalizing the actual motion over the range but of counterbalancing the variable attractive force, is to employ a spring instead of gravity to control the armature. So far back as 1838, Edward Davy, in one of his telegraphic patents, described the use of a spring (Fig. 69, p. 964) to hold back the armature. Davy preceded Morse in the use of a spring to pull back the armature. There is a way of making a spring act against an armature more stiffly as the pull gets greater. In this method there is a spring with various set screws set up against it, and which come into action at different ranges, so as to alter the stiffness of the spring, making it virtually stiffer as the armature approaches the poles. Yet another method is to employ, as the famous conjuror Robert Houdin did, a rocking lever. Fig. 70 (p. 964) depicts one of Robert Houdin's equalizers. The pull of the electromagnet on the armature acts

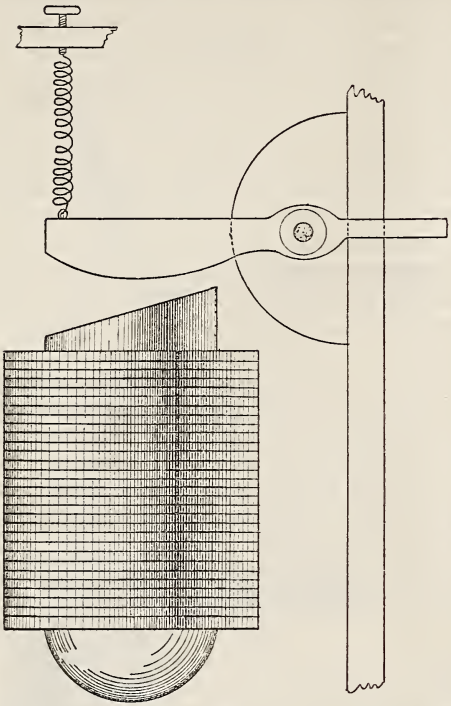
Fig. 68.



Froment's Equalizer with Stanhope Lever.

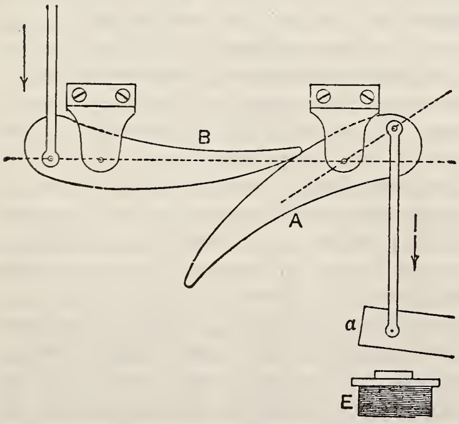
on a curved lever which works against a second one; the point of application of force between the one and the other altering with their position. When the armature is far away from the pole, the leverage of the first lever on the second lever is great. When the armature gets near, the leverage of the first lever on the second is comparatively small. This employment of the *rocking lever* was adopted from Houdin by Duboscq, and put into the Duboscq arc lamp, where the regulating mechanism at the bottom of the lamp contains a rocking lever. Here upon the lecture table is a Duboscq's arc lamp. In this pattern (Fig. 71), one lever, B, which is curved, plays against another, A, which is straight. A similar mechanism is used for equalizing the action in the Serrin arc lamp, where one of the springs that holds up the jointed parallellogram frame is applied at the end of a rocking lever to equalize the pull of the regulating electromagnet. In this lamp there is also introduced the principle of oblique approach; for the armature of the electromagnet is not allowed to travel straight towards the poles of the magnet, but is pulled up obliquely past it.

Fig. 69.



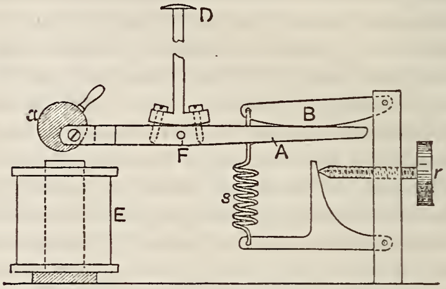
Davy's Mode of Controlling Armature by Spring.

Fig. 70.



Robert Houdin's Equalizer.

Fig. 71.



Mechanism of Duboscq's Arc Lamp.

Another device for equalizing the pull was used by Wheatstone in his step-by-step telegraph in 1840. A hole is pierced in the armature, and the end of the core is formed into a projecting cone, which passes through the aperture of the armature, thereby securing a more equable force and a longer range. The same device has reappeared in recent years in the form of electromagnet used in the Thomson-Houston arc lamp, and in the automatic regulator of the same firm.

Polarized Mechanism: Uses of Permanent Magnets.

We must now turn our attention to one class of electromagnetic mechanism which ought to be carefully distinguished from the rest. It is that class in which, in addition to the ordinary electromagnet, a permanent magnet is employed. Such an arrangement is generally referred to as a *polarized mechanism*. The objects for which the permanent magnet is introduced into the mechanism appear to be in different cases quite different. I am not sure whether this is clearly recognised, or whether a clear distinction has even been drawn between three entirely separate purposes in the use of a permanent magnet in combination with an electromagnet. The first purpose is to secure unidirectionality of motion; the second is to increase the rapidity of action and of sensitiveness to small currents; the third to augment the mechanical action of the current.

(*a.*) *Unidirectionality of Motion.*—In an ordinary electromagnet it does not matter which way the current circulates; no matter whether the pole is north or south, the armature is pulled, and on reversing the current the armature is also pulled. There is a rather curious old experiment which Sturgeon and Henry showed, that if you have an electromagnet with a big weight hanging on it, and you suddenly reverse the current, you reverse the magnetism, but it still holds the weight up; it does not drop. It has not time to drop before the magnet is charged up again with magnetic lines the other way on. Whichever way the magnetism traverses the ordinary soft iron electromagnet, the armature is pulled. But if the armature is itself a permanent magnet of steel, it will be pulled when the poles are of one sort, and pushed when the poles are reversed—that is to say, by employing *a polarized armature* you can secure unidirectionality of motion in correspondence with the current. One immediate application of this fact for telegraphic purposes is that of duplex telegraphy. You can send two messages at the same time and in the same direction to two different sets of instruments, one set having ordinary electromagnets, with a spring behind the armature of soft iron, which will act simply independently of the direction of the current, depending only on its strength and duration; and another set having electromagnets with polarized armatures, which will be affected not by the strength of the current, but by the direction of it. Accordingly, two completely different sets of message may be sent through that line in the same direction at the same time.

Another mode of constructing a polarized device is to attach the cores of the electromagnet to a steel magnet, which imparts to them an initial magnetization. Such initially-magnetized electromagnets were used by Brett in 1848, and by Hjörth in 1850. A patent for a similar device was applied for in 1870 by Sir William Thomson, and refused by the Patent-office. In 1871 S. A. Varley patented an electromagnet having a core of steel wires united at their ends.

Wheatstone used a polarized apparatus consisting of an electromagnet acting on a magnetized needle. He patented, in fact, in 1845, the use of a needle permanently magnetized to be attracted one way or the other between the poles of an electromagnet. Sturgeon had described the very same device in the *Annals of Electricity* in 1840. Gloesner claims to have invented the substitution of permanent magnets for mere armatures in 1842. In using polarized apparatus it is necessary to work, not with a simple current that is turned off and on, but with reversed currents. Sending a current one way will make the moving part move in one direction; reversing the current makes it go over to the other side. The mechanism of that particular kind of electric bell that is used with magneto-electric calling apparatus furnishes an excellent example of a polarized construction. With these bells no battery is used; but there is a little alternate-current dynamo, worked by a crank. The alternate currents cause the pivotted armature in the bell to oscillate to right and left alternately, and so throw the little hammer to and fro between the two bells.

(*b.*) *Rapidity and Sensitiveness of Action.*—For relay work polarized relays are often employed, and have been for many years. Here on the table is one of the Post-office pattern of standard relay, having a steel magnet to give magnetism permanently to a little tongue or armature which moves between the poles of an electromagnet that does the work of receiving the signals. In this particular case the tongue of polarized relay works between two stops, and the range of motion is made very small in order that the apparatus may respond to very small currents. At first sight it is not very apparent why putting a permanent magnet into a thing should make it any more sensitive. Why should permanent magnetism secure rapidity of working? Without knowing anything more, inventors will tell you that the presence of a permanent magnet increases the rapidity with which it will work. You might suppose that permanent magnetism is something to be avoided in the cores of your working electromagnets, otherwise the armatures would remain stuck to the poles when once they had been attracted up. Residual magnetism would, indeed, hinder the working unless you have so arranged matters that it shall be actually helpful to you. Now for many years it was supposed that permanent magnetism in the electromagnet was anything but a source of help. It was supposed to be an unmitigated nuisance, to be got rid of by all available means, until, in 1855, Hughes showed us how very advantageous it was to have permanent magnetism in the cores of the electromagnet. Here (Fig. 51, p. 937) is the drawing of Hughes's magnet to which I referred in Lecture III. A compound permanent magnet of horse-shoe shape is provided with coils on its pole pieces, and there is a short armature on the top attached to a pivotted lever and a counteracting spring. The function of this arrangement is as follows. That spring is so set as to tend to detach the armature, but the permanent magnet has just enough magnetism to hold the armature on. You can, by screwing up a little screw behind the spring, adjust these two contending forces, so that they are in the nicest possible balance; the armature held on by the magnetism, and the spring just not able to pull it off. If, now, when these two actions are so nearly balanced you send an electric current round the coils, if the electric current goes one way round it just weakens the magnetism enough for the spring to gain the victory, and up goes the armature. This apparatus then acts by letting the armature off when the balance is upset by the electric current; and it is capable of responding to extremely small currents. Of course, the armature has to be put on again mechanically, and in Hughes' type-writing telegraph instruments it is put on mechanically between each signal and the next following one. The arrangement constitutes a distinctive piece of electromagnetic mechanism.

(*c.*) *Augmenting Mechanical Action of Current.*—The third purpose of a permanent magnet to secure a greater mechanical action of the varying current is closely bound up with the preceding purpose of securing sensitiveness of action. It is for this purpose that it is used in telephone receivers; it increases the mechanical action of the current, and therefore makes the receiver more sensitive. For a long time this was not at all clear to me, indeed I made experiments to see how far it was due to any variation in the magnetic permeability of iron at different stages of magnetization, for I found that this had something to do with it, but I was quite sure it was not all. Prof. George Forbes gave me the clue to the true explanation; it lies in the law of traction with which you are now familiar, that the pull between a magnet and its armature is proportional to the square of the number of magnetic lines that come into action. If we take $\mathbf{N}$, the number of magnetic lines that are acting through a given area, then to the square of that the pull will be proportional. If we have a certain number of lines, $\mathbf{N}$, coming permanently to the armature, the pull is proportional to $\mathbf{N}^2$. Suppose the magnetism now to be altered—say made a little more; and the increment be called $d\mathbf{N}$; so that the whole number is now $\mathbf{N} + d\mathbf{N}$. The pull will now be proportional to the square of that quantity. It is evident that the motion will be proportional to the difference between the former pull and the latter pull. So we will write out the square of $\mathbf{N} + d\mathbf{N}$, and the square of $\mathbf{N}$, and take the difference.

Increased pull, proportional to $\mathbf{N}^2 + 2\mathbf{N}\cdot d\mathbf{N} + d\mathbf{N}^2$;
Initial pull, proportional to $\mathbf{N}^2$;
Subtracting; difference is $2\mathbf{N}\cdot d\mathbf{N} + d\mathbf{N}^2$.

We may neglect the last term, as it is small compared with the other. So we have, finally, that the change of pull is proportional to $2\mathbf{N}\cdot d\mathbf{N}$. The alteration of pull between the initial magnetism and the initial magnetism with the additional magnetism we have given to it, turns out to be proportional, not simply to the change of magnetism, but also to the initial number, $\mathbf{N}$, that goes through it to begin with. The more powerful the pull to begin with, the greater is the change of pull when you produce a small change in the number of magnetic lines. That is why you have this greater sensitiveness of action when using Hughes's electromagnets, and greater mechanical effect as the result of applying permanent magnetism to the electromagnets of telephone receivers.

ELECTROMAGNETIC MECHANISM.

There are some other kinds of electromagnetic mechanism to which I must briefly invite your attention, as forming an important part of this great subject. Of one of these the mention of permanent magnets reminds me.

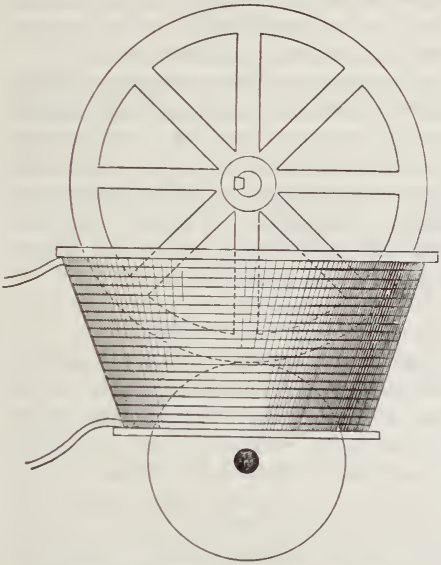
MOVING COIL IN PERMANENT MAGNETIC FIELD.

A coil traversed by an electric current experiences mechanical forces if it lies in a magnetic field; the force being proportional to the intensity of the field. Of this principle the mechanism of Sir W. Thomson's siphon recorder is a well-known example. Also those galvanometers which have for their essential part a moveable coil suspended between the poles of a permanent magnet, of which the earliest example is that of Robertson (see *Encyclopædia Britannica*, ed. viii. 1855), and of which Maxwell's suggestion, afterwards realised by d'Arsonval, is the most modern. Siemens has constructed a relay on a similar plan.

MAGNETIC ADHERENCE.

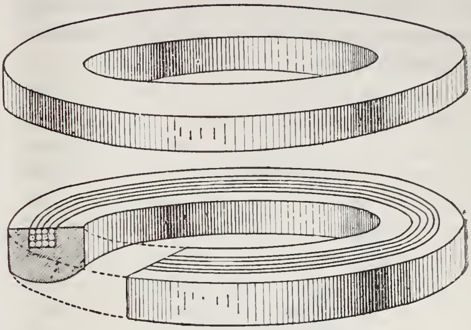
There are a few curious pieces of apparatus devised for increasing adherence electromagnetically between two things. Here is an old device of Nicklès, who thought he would make a new kind of rolling gear. Whether it was a railway wheel on a line, or whether it was going to be an ordinary wheel gearing, communication of motion was to be made from one wheel to another, not by cogs or by the mere adherence of ordinary friction, but by magnetic adherence. In Fig. 72 there are shown two iron wheels rolling on one another, with a sort of electromagnetic jacket around them, consisting of an electric current circulating in a coil, and causing them to attract one another and stick together with magnetic adherence. In Nicklès' little book on the subject there are a great number of devices of this kind described, including a magnetic brake for braking railway waggons, engines, and carriages, applying electromagnets either to the wheels or else to the line, to stop the motion whenever desired. The notion of using an electromagnetic brake has been revived quite recently in a much better form by Professor G. Forbes and Mr. Timmis, whose particular form of electromagnet, shown in Fig. 73, is peculiarly interesting, being a better design than any I have ever seen for securing powerful magnetic traction for a given weight of iron and copper. The magnet is a peculiar one; it is represented here as cut away to show the internal construction. There is a sort of horse-shoe made of one grooved rim, the whole circle of coil being laid embedded in the groove. The armature is a ring which is attracted down all round, so that you have an extremely compact magnetic circuit around the copper wire at every point. The magnet part is attached to the frame of the waggon or carriage, and the ring-armature is attached to the wheel or to its axis. On switching on the electric current the rim is powerfully pulled, and braked against the polar surface of the electromagnet.

FIG. 72.



NICKLÈS' MAGNETIC FRICTION-GEAR.

FIG. 73.



FORBES'S ELECTROMAGNET.

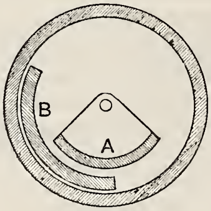
Forbes's arrangement appears to be certainly the best yet thought of for applying a magnetic brake to the wheels of a railway train.

Another, but quite distinct, piece of mechanism depending on electromagnetic adherence is the magnetic *clutch* employed in Gülcher's arc lamp.

REPULSION MECHANISM.

Then there are a few pieces of mechanism which depend on repulsion. In 1850 a little device was patented by Brown and Williams, consisting, as shown in Fig. 74 (p. 968), of an electromagnet which repelled part of itself. The coil is simply wound on a hollow tube, and inside the coil is a piece, B, of iron, bent as the segment of a cylinder to fit in, going from one end to the other. Another little iron piece, A, also shaped as the segment of a tube, is pivotted in the axis of the coil. When these are magnetized one tends to move away from the other, they being both of the same polarity. Of late there have been many ampere-meters and volt-meters made on this plan of producing repulsion between the parallel cores.

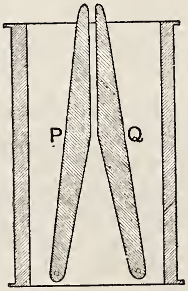
FIG. 74.



ELECTROMAGNETIC MECHANISM WORKING BY REPULSION.

Here (Fig. 75) is another device of recent date, due to Maikoff and De Kabath. Two cores of iron, not quite parallel, pivotted at the bottom, pass up through a tubular coil. When both are magnetized, instead of attracting one another, they open out; they tend to set themselves along the magnetic lines through that tube. The cores being wide open at the bottom tend to open also at the top.

FIG. 75.



REPULSION BETWEEN TWO PARALLEL CORES.

ELECTROMAGNETIC VIBRATORS.

Then there is a large class of mechanisms about which a whole chapter might be written, namely, those in which vibration is maintained electromagnetically. The armature of an electromagnet is caused to approach and recede alternately with a vibrating motion, the current being automatically cut off and turned on again by a self-acting brake. The electromagnetic vibrator is one of the cleverest things ever devised. The first vibrating electro-magnetic mechanism ever made was exhibited here in this room in 1824 by its inventor, an Englishman named James Marsh. It consisted of a pendulum vibrating automatically between the poles of a permanent magnet. Later, a number of other vibrating devices were produced by Wagner, Neef, Froment, and others. Most important of all, is the mechanism of the common electric trembling bell, invented by a man whose very name appears to be quite forgotten — John Mirand. How many of the millions of people who use electric bells know the name of the man who invented it? John Mirand, in the year 1850, put the electric bell practically into the same form in which it has been employed from that day to this. The vibrating hammer; the familiar push-button; the indicator or annunciator, are all of his devising, and may be seen depicted in the specification of his British patent just as they came from his hand.

Time alone precludes me from dealing minutely with these vibrators, and particularly with the recent work of Mercadier and that of Langdon-Davies, whose researches have put a new aspect on the possibilities of harmonic telegraphy. Langdon-Davies's rate-governor is the most recent and perfect form of electro-magnetic vibrator.

INDICATOR MOVEMENTS.

Upon the table here are a number of patterns of electric bells, and a number also of the electro-mechanical movements or devices employed in electric bell work, some of which form admirable illustrations of the various principles that I have been laying down. Here is an iron-clad electromagnet; here a tripolar magnet; here a series of pendulum motions of various kinds; here is an example of oblique pull; here is Jensen's indicator, with lateral pull; here is Moseley's indicator, with a coil and plunger, ironclad; here is a clever device in which a disk is drawn up to better the magnetic circuit. Here, again, is Thorpe's semaphore indicator, one of the neatest little pieces of apparatus, with a single central core surrounded by a coil, while a little strip of iron coming round from behind serves to complete the circuit all save a little gap. Over the gap stands that which is to be attracted, a flat disk of iron, which, when it is attracted, unlatches another disk of brass which forthwith falls down.

It is an extremely effective, very sensitive, and very inexpensive form of annunciator. The next two are pieces of polarized mechanism having a motion directed to one side or the other, according to the direction of the current. From the back-board projects a small straight electromagnet. Over it is pivotted a small arched steel magnet, permanently magnetized, to which is attached a small signal lever bearing a red disk. If there is a current flowing one way then the magnet that straddles over the pole of the electromagnet will be drawn over in one direction. If I now reverse the current, the electromagnet attracts the other pole of the curved magnet. Hence this mechanism allows of an electrical replacement, without compelling the attendant to walk up to the indicator board. The polarized apparatus for indicators has this advantage, that you can have electrical as distinguished from mechanical replacement.

THE STUDY OF ELECTROMAGNETIC MECHANISM.

The rapid survey of electromagnetic mechanisms in general has necessarily been very hurried and imperfect. The study of it is just as important to the electric engineer as is the study of mechanical mechanism to the mechanical engineer. Incomplete as is the present treatment of the subject, it may sufficiently indicate to other workers useful lines of progress, and so fitly be appended to these lectures on the electromagnet. In a very few years we may expect the introduction into all large engineering shops of *electromagnetic tools*. On a small scale, for driving dental appliances, electromagnetic engines have long been used. Large machine tools, electromagnetically worked, have already begun to make their appearance. Some such were shown at the Crystal Palace, in 1881, by Mr. Latimer Clark; and more recently, Mr. Rowan, of Glasgow, has devised a number of more developed forms of electromagnetic tools.

SUPPRESSION OF SPARKING.

It now remains for me to speak briefly of the suppression of sparks. There are some half-dozen different ways of trying to get rid of the sparking that occurs in the breaking of an electric circuit whenever there are electromagnets in that circuit. Many attempts have been made to try and get rid of this evil. For instance, one inventor employs an air blast to blow out the spark just at the moment it occurs. Another causes the spark to occur under a liquid. Another wipes it out with a brush of asbestos cloth that comes immediately behind the wire and rubs out the spark. Another puts on a condenser to try and store up the energy. Another tries to put on a long thin wire or a high resistance of liquid, or something of that kind, to provide an alternate path for the spark, instead of jumping across the air and burning the contacts. There exist some half-score, at any rate, of that kind of device. But there are devices that I have thought it worth while to examine and experiment upon, because they depend merely upon the mode of construction adopted in the building of the electromagnet, and they have each their own qualities. I have here five straight electromagnets, all wound on bobbins the same size, for which we shall use the same iron core and the same current for all. They are all made, not only with bobbins of the same size, but their coils consist as nearly as possible of the same weight of wire. The first one is wound in the ordinary way; the second one has a sheath of copper wound round the interior of the bobbin before any wire is put on. This was a device, I believe, of the late Mr. C. F. Varley, and is also used in the field magnets of Brush dynamos. The function of the copper sheath is to allow induced currents to occur, which will retard the fall of magnetism, and damp down the tendency to spark. The third one is an attempt to carry out that principle still further. This is due to an American of the name of Paine, and has been revived of late years by Dr. Aron, of Berlin. After winding each layer of the coil, a sheath of metal foil is interposed so as to kill the induction from layer to layer. The fourth one is the best device hitherto used, namely, that of differential winding, having two coils connected so that the current goes opposite ways. When equal currents flow in both circuits there is no magnetism. If you break the circuit of either of the two wires the core at once becomes magnetized. You get magnetism on breaking, you destroy magnetism on making the circuit; it is just the inverse case to that of the ordinary electromagnet. There the spark occurs when magnetism disappears, but here, since the magnetism disappears when you make the circuit, you do not get any spark at make, because the circuit is already made. You do not get any at break, because at break there is no magnetism. The fifth and last of these electromagnets is wound according to a plan devised by Mr. Langdon-Davies, to which I alluded in the middle of this lecture, the bobbin being wound with a number of separate coils in parallel with one another, each layer being a separate wire, the separate ends of all the layers being finally joined up. In this case there are fifteen separate circuits; the time-constants of them are different, because, owing to the fact that these coils are of different diameters, the coefficient of self-induction of the outer layers is rather less, and their resistance, because of the larger size, rather greater than those of the inner layers. The result is that instead of the extra currents running out all at the same time, it runs out at different times for these fifteen coils. The total electromotive force of self-induction never rises so high, and it is unable to jump a large air-gap, or give the same bright spark as the ordinary electromagnet would give. We will now experiment with these coils. The differential winding gives absolutely no spark at all, and second in merit comes No. 5, with the multiple-wire winding. Third in merit comes the coil with intervening layers of foil. The fourth is that with copper sheath. Last of all, the electromagnet with ordinary winding.

Conclusion.

Now let me conclude by returning to my starting point—the invention of the electromagnet by William Sturgeon. Naturally you would be glad to see the counterfeit presentment of the features of so remarkable a man, of one so worthy to be remembered amongst distinguished electricians and great inventors. Your disappointment cannot be greater than mine when I tell you that all my efforts to procure a portrait of the deceased inventor have been unavailing. Only this I have been able to learn as the result of numerous inquiries; that an oil painting of him existed a few years ago in the possession of his only daughter, then resident in Manchester, whose address is now, unfortunately, unknown. But if his face must remain unknown to us, we shall none the less proudly concur in honouring the memory of one whose presence once honoured this hall wherein we are met, and whose work has won for him an imperishable name.

Prof. Thompson, in replying to the vote of thanks, stated that if any of those present could assist him in discovering what had become of the portrait of William Sturgeon, or in gleaning any particulars with regard to John Mirand, he should be much indebted to them if they would communicate with him.

Miscellaneous.

NEW SOUTH WALES MINES.

The annual report* of the Department of Mines, New South Wales, contains many statistics showing the steady development of the colony as a rich mineral country, with much information about the increasing use of machinery, especially in gold mining, as succeeding the "rushes" made by ill-equipped "gold hunters." The facts given indicate throughout that metal getting continues to settle down to a recognised permanent industry under experienced supervision, instead of being a temporary haphazard occupation for hopeful but unskilled adventurers.

The report,† the size of a folio Blue-book, consists of 253 pages, and in addition to the summarised report (pp. 5-52) by the under-secretary for mines, includes the following departmental reports:—Wardens' and mining registrars' reports (53-127), which are 128 in number, and give particulars of the mining operations for each "division" of each "district;" the inspector of mines' report (128-135); superintendent of drills' report (136-174), with thirteen full-page lithograph sections of bores, and four of "water auger" bores, accompanied by a map of the colony showing the position of wells and bores, and an index of 260 wells with tabulated particulars; report of the examiner of coal fields (175-198), with many wood-cuts, and returns of accidents; report of progress of the geological survey of New South Wales (198-253), including appendices by the Prospecting Board, the geological surveyor (209-230), the palæontologist, the museum curator, the analyst, and the superintendent of caves.

Among the statistics given in the under-secretary's report are the following:—The total area of Crown lands held under lease for mining purposes is over 205,000 acres. The fresh applications to lease mining land, though far below the exceptional year 1888, amounted to 2,285, the number for search for shale yielding mineral oil being largely increased.

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* Annual report of the Department of Mines, New South Wales, for the year 1889, dated Sydney, 12th March, 1890. Printed in accordance with resolutions of both Houses of Parliament, 78, A, Sydney. Charles Potter, Government printer.

† There is no progressively-paged table of contents, or list of the included departmental reports, or any index. Such table of contents as there is is grouped under headings—gold, coal, &c, but not alphabetically. The inspector of mines' report, with its divisions, gold, silver, copper, tin, &c., is entered under gold, so is the report of the superintendent of drills, which includes water augers. The valuable appendices (with diagrams) on diamond drill sections and water-auger sections are not entered in this table. The general contents are therefore mentioned in sequence here.

The applications to the Prospecting Board for aid amounted to 495, of which 109 were granted, 66 refused, while 320 remained to be considered, and the analyst, with his assistants, examined 3,222 samples of ores and minerals. On the 30th of September the new Mining Act came into force. The aggregate depth of the diamond-drill bores for the year was 7,853 feet, being less than in 1888, owing to the greater depths and the meeting with harder rocks, while the cost increased 3d. a foot. The water augurs bored 1,448 feet, at a cost of £1 8s. 2d. per foot, not including office expenses. The yield of gold was larger than in any year since 1883, being £434,070, bringing the grand total since 1851 up to over £37,500,000. The belief is expressed that whatever may be the future with regard to alluvial gold, whether it is nearly exhausted or whether fresh areas will be found, "as regards our auriferous lodes........there can be little doubt that we have barely commenced to open them." The summary given on pages 17 to 21 of the wardens' and mining registrars' reports, mentioning the great successes, shows how numerous they are; 83 tons of stone, 128 ounces of gold; 4 tons, 45 ounces of gold; 56 tons, 278 ounces of gold; 3,137 tons, 24,8250 ounces of gold; 8,300 tons, 29,000 ounces of gold, and so on. The great majority of the returns are, however, far below that. A large number of new mines have been recently opened up, from which as yet only trial crushings have been made. One mine in Yalwai is mentioned as being worked as a quarry, and having machinery to treat 350 tons of "stone" per week.

During the year over 114,000 oz. were sent to Sydney Mint, as against over 82 in 1888 [p. 21]. "The output of gold, according to the returns furnished by the mining registrars, is less than the quantity sent to the mint by 1,537 oz. This is due to the fact that, as usual, the efforts of the mining registrars to obtain complete returns."* The number of men engaged in gold mining was 10,192—4,569 in alluvial work and 5,063 in quartz mining. A list is given of 335 samples from various districts that have been assayed. Some of the higher figures of ounces of gold per ton of 'stone' are 30, 33, 35, 36, 38, 47, 57, 69, and in one exceptional case of pyritous sand, 204. [These are assay values, not returns from actual working.] There are, on the other hand, 67 cases in which the amount did not reach 1 oz., the lowest being 10 dwts. Of the whole 3,007 samples assayed during the year, 1,763 yielded *nil*, and 909 yielded under 10 dwts. per ton. It may be mentioned 1 oz. is considered a fairly good return, and less than that may be worked at a profit. (*Infra.*, even 5 dwt.)

The coal output shows a steady increase year by year. Last year the total raised was over 3½ million tons, of which over 1¼ went for home consumption, rather more to the other colonies, and over a million to foreign ports. At an average of 8s. 11d. per ton, the total value was £1,632,848. Details are given of different mines, and a summary shows that, of the whole output, 2½ millions were from the northern district. The "petroleum oil shale," from the four mines worked, amounted to over 40,000 tons, but the value dropped from £2 2s. to £1 18s. per ton. In silver and silver-lead ore there is also a great increase year by year, till last year the amount raised reached very close on £2,000,000 in value. The Department assayed 3,009 samples, and particulars of 150 are given. Many of these run over 100 ounces to the ton, and among the remarkable cases are 386, 397, 400, 472, 487, 1,215, and 7,482, this last being calcite with chloride of silver. The tin outpit began to decline in 1883, and has steadily declined, till it was last year half the value of that in 1882. Copper has slightly improved in output. Under "Iron" is mentioned the following:—"An attempt has been made by Mr. Brayenhall to make gas-pipes, &c., from iron smelted from the ore, and taken direct from the ore to the furnace (cupola) without first making it into pig iron, and hopes are entertained that he will succeed." The other metals referred to are antimony, cobalt, nickel, manganese, zinc, platinum, bismuth, graphite, and mica.

The steady increase in the use of machinery in mining is shown by the returns, which give its approximate value for gold at over £396,000, that for silver being over £340,000, for copper about £80,000. For other metals the returns are incomplete. There is a tabulated statement (p. 52) of the machines employed, the horse-power of engines, &c. The inspector of mines' report gives 15 fatal and 16 non-fatal accidents as the total casualties for the year. His notes on the work of the Prospecting Board are full of information as to the examination of new districts, and of fields where work has been commenced but deserted. In many cases advice is given to resume work; in some, to continue on a more extended scale. Keeping the progressive work of sinking and driving well ahead of the removal of mineral is urged in some cases as the only way to assure success. The great advantage of having an official Prospecting Board is made manifest in many ways. It has pointed out that in some cases a return of gold of only 5 dwt. from each ton of "stone" may be made payable.

The superintendent of drills' report, with its nine appendices, speaks of the year as "successful in every way," as to the number of feet bored, the total cost per foot, the total earnings of the drills, per-centage of cores saved, &c. The average cost per foot of boring has been 12s, exclusive of office and store expenses, or 14s. 3d. with. The per-centage of core saved has been 89·33. Of the diagrams of cores given, five are of 3 in., seven of 4 in., and one of 2½ in. The drills are the property of the Government, and are hired together with men and skilled supervision.

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* It is especially in regard to alluvial workings that the difficulty lies in getting full returns. It is the same in the South African fields, where it is believed the official returns of the Natal and Cape export do not account for a half that has been obtained Though the New South Wales return for alluvial is £3,920 for 1889, as against £1,865 for 1888, the report speaks of the return as being "so meagre as to be utterly valueless." It is much to be regretted that the mine owners cannot be induced to furnish complete returns, as they would be most valuable for statistical purposes, and could not possibly injure the owners of mines, while they might materially help forward the mining industry.

The report of the Geological Survey, in addition to practical prospecting, &c., contains information on the determination of the ages of various beds, and on palæontology. The palæontologist, Mr. R. Etheridge, jun., especially mentions the "fast accumulating evidence of the strong relation which appears to exist palæontologically between our lower carboniferous beds and the European carboniferous limestone generally."

Correspondence.

THE INTERNATIONAL LITERARY AND ARTISTIC CONGRESS.

Mr. John Leighton writes:—In consideration of the great efforts made by our Society in the copyright laws, I think that the hints I ventured to express at the Mansion-house at the meeting of the Congress, when the Lord Mayor presided, should find echo in the *Journal*. To England belongs the honour of having been the first to acknowledge a principle of property in literary ideas in the days of Queen Anne, and in artistic expressions in the days of the Georges, whilst it was the work of our own day to approach a codification, under the presidency of Sir Charles Eastlake, P.R.A., assisted by the first artists of that day, at the house of the Society of Arts, an attempt that, with official revision not to the taste of all the committee, became law in 1862. Since the codification of the Acts under the Society of Arts, I have assisted at the Antwerp Congress, and upon the occasion of the last French International Exhibition by sitting at the Louvre, and at the Ecole des Beaux Arts, upon a committee that has its locale in Paris, and sits *en permanence*. From long experience I should advocate a union of all the arts, both literary and artistic, including music and the drama. Having been the victim of American process piracy, I feel that something should be done, by argument and persuasion, to prevent the transfer for a few dollars of works that have cost European enterprise thousands. Art, speaking a universal language, suffers the most, music the next, and literature perhaps the least (that is to say, in Europe), as it has to be translated.

Notes on Books.

Metallurgy of Silver, Gold, and Mercury in the United States. By Thomas Egleston. Vol. II., Gold and Mercury. London: *Engineering*. 1890.

The first volume of this work was published in 1887, and dealt with silver. The second, which has just been issued, deals with gold and mercury. The work is voluminous in character, and the information given is copious. As many as 140 illustrations of apparatus and appliances used are given, together with full statistical details and descriptions of various types of apparatus, special mines, &c. The book begins with a history of the discovery of gold in America, and a description of the earlier methods and apparatus employed before machinery came into use. The second chapter deals with hydraulic mining, which is very fully treated. A chapter on drift mining leads to an account of gold-stamping and amalgamating machinery. After this follows a description of Plattner's process, in which gold is converted into a soluble chloride, which can be washed out with water. The application in America of this well-known and important process is fully dealt with. Then follows a chapter on the parting of gold and silver, which includes a full account of the United States mints. Tne final chapter of the book is devoted to mercury. The book contains an enormous amount of information, given in rather a diffuse fashion.

Elementary Text-book of Trigonometry.—By R. H. Pinkerton. Blackie and Son.

This is a new edition of the convenient small text-book on trigonometry prepared by Mr. Pinkerton. It contains two new articles, giving an account of the method of proportional parts, and its application to logarithmetic and trigonometric tables. There are also a selection of the Science and Art Department examination-papers, and those of the London University Intermediate Examinations.

General Notes.

Lectures on Agriculture.—Yesterday, the 9th inst., a course of eighteen to twenty lectures on the science of agriculture was commenced at King's College, London, by Mr. Fred. J. Lloyd. They will be continued on Thursday evenings from 7.15 to 8.15 p.m. The lectures are especially adapted to assist those who are studying for the examinations of the Surveyors' Institute, the Royal Agricultural Society, or the advanced examinations of the Science and Art Department.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Proceedings of the Society.

CANTOR LECTURES.

SUGAR, COFFEE, TEA, AND COCOA, THEIR ORIGIN, PREPARATION, AND USES.

By Richard Bannister.

Lecture I.—Delivered April 28th, 1890.

Sugar: what it is.

The sense of taste, which resides in the gustatory nerves of the tongue, has evidently been given to guard against taking in by the mouth any corrosive or injurious substances, and also for the purpose of imparting pleasure to the necessary act of eating and drinking, by which we obtain our food. This sense of taste has, without doubt, been given to man as a source of true enjoyment, and is found to be so by all who only eat and drink to live, and who by moderation and due care supply to the stomach proper nutriment for digestion, and for building up and maintaining a healthily nourished body. When, however, our taste is unduly indulged and stimulated, it has proved a fruitful source of mischief, on account of the excessive work thrown on the organs of digestion.

The sense of taste classifies different substances according to flavour, and naturally arranges them into four primary divisions, viz., sweets, bitters, salines, and acids. Sugar, when taken into the mouth in a solid state, is speedily dissolved by the saliva, and thus assumes the physical condition in which it is most capable of stimulating that division of taste which is known to us under the name of sweetness. Sugar is an important constituent of milk, and as it is the most easily digested substance which maintains animal heat, it is not surprising to find it in the milk of the mammalia, the natural food of the young during the first period of their existence. Though in its various forms it is a very important constituent of a normal diet, yet of itself it will not sustain life, and it has been proved that animals fed on sugar alone soon died if they had not at the same time some kind of nitrogenous food for building up the tissues of the body.

Physiologists tell us that, speaking generally, sugar when taken into the stomach passes through its walls in an unchanged condition into the blood, but that it ultimately, under normal circumstances, becomes converted into carbonic acid and water—a change which is attended by the liberation of a considerable quantity of heat. Hence sugar, whether taken as such, or formed during digestion from the starchy elements of our diet, is one of the agents primarily concerned in maintaining the temperature of the body. By reason also of its chemical and physical properties it diminishes the oxidation of fatty and nitrogenous substances, and thus indirectly contributes to the weight of the body, and also to the deposit of fat in the subcutaneous tissues, whereby the loss of the body heat is retarded or largely prevented.

The instinctive love of sugar seems to point out how well it is adapted to our natural wants. This love is not confined to any particular nation, but is general, and from the Table on p. 974 it will be apparent that wherever sugar can be easily obtained the consumption is enormous. The Table would be of greater interest if it were more comprehensive, and included other countries besides those enumerated, but such returns cannot be obtained.

It would appear that in the southern countries of Europe, where the temperature is higher and the facilities of locomotion small, the consumption is less than in more northern climes, where the cold of winter compels the population to keep up the temperature of the body, and where facilities are more general for the supply of an article to keep pace with the demand for it.

In Great Britain and the United States the consumption per head is greatly in excess of all other countries, and although the United States took much less comparatively than we did ten years ago, yet in the return for 1887 it is shown that whilst the consumption of sugar increased in Great Britain 1·2 lbs. per head, in the United States the increase was 22·9 lbs. during the same period.

If this rate of progress is maintained, the people of the United States will soon occupy the premier position; and there is reason to believe that they have already attained to this distinction, chiefly on account of the large quantities of sugar used to preserve canned fruits, which are so extensively imported into this and other countries for consumption.

TABLE I.—LBS. SUGAR CONSUMED PER HEAD.

Countries.	1880–4.	1887.
Spain	5·1	—
Italy	7·6	—
Russia	7·7	9·0
Portugal	9·5	—
Austria	13·2	12·1
Germany	15·0	18·9
Belgium	15·7	—
Sweden	17·5	—
France	22·6	27·0
Switzerland	22·7	—
Holland	28·3	23·1
Denmark	29·6	—
United States	38·0	60·9
Great Britain	68·8	71·0

TABLE II.

The consumption of raw sugar in the United Kingdom was in—

Year.	Tons.
1700	10,000
1710	14,000
1731	36,100
1741	40,883
1751	38,108
1761	56,400
1771	62,746
1780	61,034
1791	70,160
1801	138,689
1811	161,337
1821	152,844
1831	189,050
1841	202,881
1851	311,677

TABLE III.—CONSUMPTION OF RAW AND REFINED SUGAR IN THE UNITED KINGDOM.

Year.	Raw.			Refined.			Total Tons.
	Tons.	Lbs. per head.	Average price per cwt. in bond.*	Tons.	Lbs. per head.	Average price per cwt. in bond.*	
Average.							
1855-9	383,263	—	28 10	13,474	—	38 3	396,737
1860-4	446,956	—	24 1	18,338	—	34 3	565,294
1865-9	525,494	—	22 3	40,496	—	31 8	565,990
1870-4	603,608	—	24 1	96,446	—	33 10	700,054
1872	585,297	41	26 2	88,286	6·2	36 4	673,583
1873	630,397	44	24 0	109,872	7·6	33 10	740,269
1874	641,272	44	22 5	128,681	8·9	30 8	769,953
1875	740,382	51	21 2	129,732	8·9	30 4	870,114
1876	681,483	46	21 0	129,913	8·8	29 5	811,396
1877	751,253	50	25 9	162,760	10·9	33 9	914,013
1878	680,608	45	21 6	154,922	10·3	29 3	835,530
1879	821,682	54	20 3	143,508	9·4	27 5	965,190
1880	786,127	51	21 9	145,541	9·5	29 3	931,668
1881	873,361	56	21 9	131,660	8·4	28 11	1,005,021
1882	925,996	59	21 1	131,947	8·4	28 8	1,057,943
1883	925,821	58	20 1	156,902	9·9	27 2	1,082,723
1884	892,069	55	15 6	201,989	12·6	20 11	1,094,058
1885	899,599	55	13 10	255,475	15·7	18 2	1,155,074
1886	731,071	45	13 0	307,296	18·7	16 8	1,038,367
1887	841,175	51	12 1	335,241	20·2	15 8	1,176,416
1888	802,147	48	13 5	334,234	20·0	17 6	1,136,381
1889	840,689	50	—	440,483	26·1	—	1,281,172

* Duty abolished 1875.

Sugar lends itself so readily to disguise disagreeable flavours of bitterness, acidity, and saltness, that it will always be a popular adjunct to unpleasant foods or medicines, and will enter largely into the composition of prepared fruits and confections for the million.

To guard against the abuse of sugar, it is only right to point out that an excess of sugar in the mouth diminishes the activity of the salivary secretion, and in the stomach is very liable to undergo acid fermentation, giving rise to one form of acid dyspepsia.

It should therefore be used in great moderation in special constitutional conditions, as, for example, the gouty and rheumatic, and avoided altogether in the case of diabetic persons.

Sugar and sweetness have been for ages indissolubly linked together, and substances possessing a sweet flavour, though not derived from the vegetable kingdom, and even when possessing poisonous qualities, have been called sugar on account of their sweetness to the palate. Thus the acetate of lead is often called sugar of lead; and the true sugars, whether derived from fruits, milk, or vegetable juices have all, from their sweetness, been put in one class, although in composition, appearance, and flavour, they vary.

The progress made in organic chemistry has led chemists to study more closely the composition and properties of sugar derived from different sources, and now the term "sugar" is, in chemistry, applied to a very large class of organic substances composed of carbon, hydrogen, and oxygen, termed carbohydrates. The oxygen and hydrogen present in them are in the same proportion as they exist in water.

The sugars are again classified according to their chemical or optical properties; but for our present purpose it is only necessary to note that in commerce the term sugar is generally understood to apply to the crystallised sugar obtained from the sugar cane, or to sugar of the same composition and physical properties derived from the beet, sugar maple, sorghum, palm, or other vegetable substance, and in sufficient quantity to make it an article of commerce. For brewing purposes cane sugar is often used on account of its wide distribution, but from investigation and experiment it has been found that cane sugar specially modified by chemical treatment and sugar manufactured from starch are more suitable, and these have now, at many large breweries, displaced raw cane sugar.

Again, in confectionery and jam making, cane sugar, in the form of "loaf," is generally employed, but in the commoner descriptions of jam, which are made from poor fruit, or from the pulp deprived of a greater part of its juice, which has been used for jellies or syrups, a liquid dextrinous starch sugar is in large demand, on account of its giving body to the jam, and supplying to some extent the properties which only sound good fruit naturally possesses.

Pure cane sugar is a carbohydrate, having the chemical composition $C_{12}H_{22}O_{11}$. Its crystals are hemihedral, of the monoclinic system, and emit light when broken. It is insoluble in absolute alcohol, but exceedingly soluble in water. This property of solubility has been taken advantage of in purifying the crystals of cane sugar from adhering syrup, and a method has been devised of washing sugar containing syrup with alcohol diluted with certain proportions of water. The crystallised sugar could thus be quickly estimated, and though not chemically accurate, sufficiently so for ordinary commercial purposes. Cane sugar does not reduce copper as grape sugar does, and it is not directly fermentable.

When heated it melts at 320° Fahr.; at a slightly higher temperature it decomposes into dextrose and levulosan, and at 410° Fahr. caramel is produced. Above this temperature various gaseous bodies are produced.

Cane sugar forms definite chemical compounds called sucrates, with certain mineral substances as lime and strontium, and efforts have been made to obtain by these combinations commercial sugar from cane and beet juice, but without success.

Cane sugar is converted into invert sugar ($C_6H_{12}O_6$) by the action of acids, heat, yeast, and many other agencies, and this property of inversion is the great trouble of the sugar refiner, who has to adopt different means, according to the circumstances of the case, to prevent this change. It will be referred to later on that invert sugar not only will not crystallise itself as cane sugar does, but it also prevents definite quantities of cane sugar passing into the crystalline form.

In fact, the great discovery of the age in our sugar industry would be a method of converting invert and other sugars into cane sugar. All attempts to solve this problem have hitherto failed, but the practical solution of it would work a revolution in our sugar industry by opening up new sources of supply, and modifying our present methods of sugar refining.

SUGAR: ITS HISTORY.

Sugar being very widely distributed in the juices of plants, trees, and fruits, there is very great difficulty, from a historical point of view, in tracing its exact origin. Honey, as the natural secretion of bees, was well known as typical of sweetness, but it would appear that the bee's faculty of obtaining sugar from flowers was not realised, it being supposed that the bee made the honey within itself out of the extract it obtained from the flowers. Thus we find that Theophrastus, 371-286 B.C., describes sugar as a sort of "honey extracted from canes or reeds." Strabo also states, on the authority of Nearchus, the admiral of Alexander, "that reeds in India yield honey without bees." Another writer, Dioscorides, describes it "as a sort of concreted honey, found upon canes in India and Arabia Felix; it is in consistence like salt, and is, like it, brittle between the teeth." Pliny says it is as "honey collected from canes like a gum, white and brittle between the teeth; the largest is the size of a hazel nut; it is used in medicine only." It is evident from these quotations that the Greeks and Romans had no reliable knowledge of the methods of extracting sugar from the vegetable substances containing it, but it can be inferred that the sugar was obtained from a species of cane or reed, and that it was supposed the sugar oozed out, and, on exposure to the air, solidified. Sugar cannot, however, be obtained from the cane without the aid of art. Naturally the juice will not flow out, and consequently pressure must be exerted, or the canes must be sliced and macerated. As Pliny states that the lumps of sugar may be as large as a hazel nut, it has been conjectured that the sugar he refers to was sugar candy of Chinese manufacture. This has been largely produced, of two qualities, for many centuries, and imported into India for consumption. From thence it might find its way into Europe, but the quantity obtained must have been small when so rare as to be looked upon only as a medicine.

The Saracens in the 9th century having become possessed of certain islands in the Mediterranean, began to cultivate the sugar-cane which they brought from Arabia, and to them we are indebted for the introduction of the sugar-cane, and also for the manufacture of sugar from it. In the 12th century sugar could be more cheaply imported from Sicily than from Egypt; and the Crusades, which did so much for commerce, were the means of bringing sugar under the notice of the sturdy warriors of France and Britain, who, in their turn, introduced it into their respective countries. The Saracens, before the Crusades began, had extended their territory, and settling down in Spain, they cultivated the sugar-cane extensively, and established sugar factories at Valencia, Granada, and Murcia. As the Spaniards and Portuguese became maritime powers, and extended their conquests to the American continent, they took out the sugar-cane for cultivation. Historians, however, differ in their views as to whether the cane was or was not indigenous to the American continent, but the balance of evidence is in favour of its having been a native of the West Indies and the New World in general. It is beyond the limits of doubt that these European explorers did take with them a knowledge of the best known methods of extracting sugar from the cane, and the factories they established in the West Indies increased in number and importance. Peter Martyr, writing in 1530, states that in 1518 there were twenty sugar works in St. Domingo, established by the Spaniards, and goes on to say:—

> "It is marvellous to consider how all things increase and prosper in the island. The canes or reeds wherein the sugar groweth are bigger and higher than in any other place, and are as big as a man's wrist, and higher than the stature of a man by the half. This is more wonderful, that, whereas in Valencia in Spain, where a great quantity of sugar is made yearly, whensoever they apply themselves to the great increase thereof, yet doth every root bring forth not past 5 or 6, or at most 7, of these reeds, whereas at St. Domingo 1 root beareth 20, and sometimes 30."

Gradually, the production of sugar centred in the West India Islands, and spread to the mainland adjacent. For about 300 years the sugar consumed in Europe was brought almost entirely from the West Indies, a small quantity only being imported from the East Indies, from causes to be explained hereafter.

One of the earliest records of sugar being used in Great Britain appears in the accounts of the Chamberlain of Scotland, 1319, in which it is set down at 1s. 9½d. (more than an ounce of standard silver) per lb.

In 1459, sugar continued to be a great luxury, for in that year Margaret Paston, writing to her husband, begs that he "vouchsafe" to buy her a pound of sugar.

In the churchwarden's account of St. Mary-at-Hill, London, 1516, there is the following entry.—"At Cambridge's Obit., sugar, 1 lb, 7d." In the list of the viands provided for the funeral repast of Sir John Redston, Lord Mayor in 1531, sugar is set down at 7d. lb. In the household book of the Dean of Salisbury, 1625, there is set down "lb. of hard sugar 16d., of powder do. 14d." Anderson's "History of Commerce" informs us as to the market price.

At the restoration of Charles II. the Parliament, observing the great detriment which the sugar trade, open to all nations, did to the kingdom, confined it absolutely to our own people by several Acts of navigation, in consequence whereof the ports of London and Bristol soon after became the great magazines of sugar for supplying that article to all the north and middle parts of Europe, reducing the Portuguese sugars of Brazil in time from £8 to £2 10s. per cwt. This continued until the French, in their turn, so greatly improved the quantity and quality of sugar obtained from their colonies as to be able to undersell us in most parts of Europe. The European supply of sugar thus came mainly from French sources, and though Holland still drew its supply chiefly from its own colonies, other countries had to buy French produce. Later on, through continental wars, this system received a crushing blow, and it was thought by many that Europe must be solely indebted to England and Holland for its sugar supply, or go without altogether.

It followed, therefore, that during the wars of the French revolution, the external commerce of the Continent was so crippled, that colonial sugar could not be imported, and Europe was not suited to the growth of the sugar-cane. Efforts had therefore to be made to obtain an internal source of supply, and experiments were conducted with beet, carrots, and other sweet roots indigenous to the middle and south of Europe, to see whether sugar sufficiently pure for the table could be produced from them. The first results were not satisfactory, but Achard, of Berlin, persevered with beets, and was so successful that the Prussian Government gave him a special reward for his experiments. His process was a remarkable one. He cleaned the beet from dirt and other impurity, and then boiled it till it was so far softened that a straw could be thrust into it; the roots were then sliced, submitted to pressure, and the juice extracted. The mass remaining in the press was treated with water, and again pressed to extract more syrup, and even after this treatment the pulp was considered rich enough for fermentation to produce alcohol. The first juice was strained and boiled down to two-thirds of its bulk; it was again strained through a thick blanket, and then boiled down to half its bulk, and again strained through flannel. This liquid, or syrup, was then put in shallow pans in a room kept at a temperature of 120°. Crystallisation began by the formation of hard crystals on the surface of the liquid, which were broken down to hasten further crystallisation. After a time, a gummy skin appeared at the top of the liquid, the pan was then removed from the hot room, and the contents were pressed in strong linen bags previously moistened with water. What remained in the linen sack was a brown sugar, resembling what is now known in the trade as muscovado. Achard's experiments were repeated by a commission of the French National Institute, but the quantity of sugar obtained only amounted to 18 lbs. for every 1,152 lbs. of fresh beet treated, or 1·5 per cent. The sugar so obtained was of bad colour and offensive flavour, and had to be further purified to fit it for use as an article of diet. Lampadius of Freyberg experimented with Achard's process, but it proved a failure commercially.

When peace was restored after the fall of Napoleon, colonial sugar was again imported into France. Although the duty upon it was very high, and beet sugar was produced free of duty, yet the foreign sugar displaced the home grown, and to stop this displacement the import duty on foreign sugar was greatly increased. This increased tariff had the desired effect, for it placed the production of beet sugar on a firm foundation, and made it a successful industry. In 1828 the yield of sugar from beet amounted to 4,000,000 kilos., and in 1838 to nearly 40,000,000 kilos., or a tenfold increase. The beet-root sugar was sold in France at the same price as its highly-tariffed rival, consequently the profits made by the beet-root sugar maker were immense. The public complained at the price charged for the home product, and the colonists also made their grievance felt. The result was that the Government could not withstand the attacks from within and without, when accompanied by a serious loss of revenue through the substitution of the duty-free sugar in place of foreign manufactured. A small duty of 16½ francs per 100 kilos. was imposed on beet sugar in 1838, and in 1840 the duty was further increased to 27½ francs, or about 11s. per cwt. Even then there was a differential duty of 20 francs per 100 kilos. in favour of home grown beet sugar, which was a margin more than sufficient to cover the extra cost of manufacture. The complaints made by the home manufacturer that he was unfairly handicapped in the competition were to some extent neutralised by the affirmations of the colonial producer that the bounty placed him at a very great disadvantage. The truth seemed to be between the two extremes, for some of the home manufacturers were unable to continue their business, whilst at the same time the returns from the duty did not come up to the estimate of the revenue authorities. In these circumstances the drastic measure was proposed of suppressing the beet-root sugar industry altogether by abandoning the cultivation of beet, and paying a compensation of 40,000,000 francs to the planters. This proposition, seriously entertained by many who wished to deal out justice to the home and colonial producer of sugar, had a marked effect on the beet-root grower. His views of hardship were greatly modified, and he was willing to agree to a specified annual increase of duty (5 francs per 100 kilos.) till the duty on home and colonial sugar was equalised. The change commenced in 1844, and in 1848 the duties were uniform. The ruin of the home grower, though prophesied, was not effected by the change, for the falling off in the supplies of sugar from the French colonies, which took place between 1842 and 1848, when slavery was abolished, and other changes in the sugar industry of the world, gave such advantages that the beet-root manufacturer had practically a monopoly of the home market. He did not, however, enjoy continuous prosperity, but from the profits realised he was able to improve his methods of manufacture, till in 1858, the sugar estimated to be produced from the beet crop was 150,000,000 kilos., or about 150,000 tons. Ten years later the production was doubled.

The growth of the beet-root sugar industry in France has been somewhat minutely traced, because it fairly represents what has taken place in Holland, Belgium, Germany, and Russia. It is remarkable that an industry created as it was by the exclusion of foreign sugar from the Continent, and fostered by the imposition of heavy duties on its rivals, should have risen into such prominence, and that even after the privileges it enjoyed were taken away it should be able not only to hold its own in the country of its production, but be imported largely into other countries to take the place of its old competitor, colonial-grown cane sugar. Other anomalies connected with the sugar industry have since arisen, but they will be treated in a subsequent part of this lecture, when considering the burning question of "Bounties" which now agitates the Governments of this and other countries.

MAPLE SUGAR.

Sugar was produced in large quantities in Canada and the United States from the *Acer saccharinum*, or sugar maple. The tree is valuable for timber as well as for sugar production, and as in the vicinity of towns timber has been in demand for building purposes, whilst facilities for the transit of goods have at the same time been increased, it has happened that the maples have been cut down, and sugar for the use of the population has been obtained from distant sources. In thinly populated districts the maple sugar industry is still carried on, and as the sugar is made in early spring before farming operations have fully commenced, it helps to swell the returns of the farm, because the outlay in securing the sugar crop is very small, and the profit is large.

The tree is pierced in early spring to a depth of two inches, and when the juice begins to flow as much as three gallons per day can be obtained from a single tree. The flow of the sap or juice is very uncertain, being largely dependent on climatic conditions, and varying from day to day, according to the weather. As soon as the foliage of the tree begins to form the sap ceases, or becomes so sour that it is useless for sugar making.

The produce of sugar from sap may be reckoned, on the average, as 1 lb. of sugar for every five gallons of sap, and the yield of a tree per season will be about 4 lbs. of sugar. The methods in use for clarifying and concentrating the juice are very primitive, but they closely corrrespond with what is done in the West India Islands when common muscovado sugar is produced, and the operations must be conducted with even greater rapidity on account of the juice being in a condition to pass rapidly into fermentation and decomposition. Maple sugar crystallises very easily in the mother liquor, and in this respect also resembles sugar from the cane.

SORGHUM.

Of late years certain grasses, which at one period of their growth are rich in sugar, have been cultivated in the United States. These grasses—chiefly *Sorghum vulgare* and *Sorghum saccharatum* have been under special cultivation and investigation by the United States Department of Agriculture, and elaborate reports on the subject have been issued. The crop has been cultivated because it appears to stand against the frost better than the sugar-cane, and it also arrives at maturity at a different season of the year. It was thought therefore that sorghum cultivation might supplement cane-growing, and thus one central factory might be used for manipulating the two crops. The industry, however, is not a large one, and as the quantity produced is on the descending scale it is apparent that that there is either some defect of quality, or that the cost of production is too high for commercial purposes.

In 1880, trials were made with sorghum growing on the Duke of Rutland's estate at Belvoir. Our variable climate, however, speedily put an end to these experiments. In the spring of that year the cold was very great and continuous, consequently the plants made very slow progress in growth, and though the month of August was favourable, the succeeding months were very unseasonable, and the crop never arrived at maturity. Under more propitious circumstances other results might have been obtained, but the experiment proved that a crop depending for its success so much upon warmth and regularity of temperature could never be depended on in a climate like ours.

In this, as in other crops, local circumstances may sometimes favour the growth and cultivation of a special plant or tree for the production of sugar, but as a rule the sugar of commerce known as cane sugar is produced from the cane or beet; and our remarks must therefore be confined to them in a general lecture, especially when, in this country at least, the sugar of commerce is obtained entirely from these two sources, the raw sugar for direct consumption being the product of the cane, and the refined sugar being more or less a mixture of the two.

The sugar-cane is in reality a gigantic grass. Its varieties are too numerous to recapitulate. The principal are the *Bourbon*, which came originally from the Malabar coast; the *Otaheite*, much cultivated in the West Indies; the *Batavian*, the *Chinese*, the *S. Pacific*, and the *Elephant cane* of Cochin China, which justifies its name by reaching the astonishing height of 11 feet in six months. In structure the cane has a knotty stalk, and at each knot a leaf and an inner joint. The root-bearing portion, or stole, is divided into two parts, the first formed of several peculiar joints varying in number from five to seven, divided from each other by a radicle leaf. The first cane joints are also provided with rudimentary roots, which develop when necessary until they form a basis sufficiently strong to support the cane itself. The roots are slender, with a few fibres at their extremities, and are seldom more than 1 foot long. The joints of the stalk vary from 40 to 80 in number; the individual joints themselves run from 2½ to 3 inches in length in the latter, to 8 to 9 inches in the former, and even in the same plant have various differences of length and thickness. The sap vessels are large and very numerous; the leaves, alternate and divided into two parts by a nodosity, expand on the top of the plant like a fan. From the centre of the last radicle knot the germ of the first cane joint springs, and requires from four to five months for its entire growth. During this time some 15 to 20 joints spring from it in succession, the period of maturity of each being ascertained by the decay of its leaf. Under cultivation very few of the canes ever bloom, and consequently the propagation has to be effected entirely by cuttings, any part of the stem having a perfect eye or bud serving the purpose.

On ripening, the canes are cut as close to the stoles as possible—the juice of the lower joints being richest in sugar. The top and the two upper joints are discarded, their juice being of very poor quality.

As to climate, anything approaching cold opposes growth, and so the whole of Europe is unfit, with the exception of a small portion of Spain. In certain parts of India the juice is sometimes spoiled by frost, and this is the case in Louisiana. An almost ideal soil is the "brick mould" of the East and West Indies—a mixture of sand and clay, hoed and dug with ease—constituted so as to allow air and moisture to penetrate to some depth, draining well, yet moist in the hottest seasons. Some of the best sugars are produced on limestone soils.

The importance of good manure will be apparent when it is considered that 1,000 tons of cane take from the soil nearly 5 tons of mineral matter, and it is obvious that if the soil cannot supply this in a form capable of assimilation, a full crop of sugar cannot be raised. The most important matters appear to be potash, silica, phosphoric acid, lime, and magnesia, with a certain amount of nitrogen. Good stable manure and well fermented farmyard dung are much superior to superphosphate, which suits root crops better than graminaceous plants. Green soiling is much in favour, and attention is beginning to be paid to proper rotation of crops.

The canes having been gathered, the next operation is naturally that of extracting the juice. This is contained in small cells; and there are, broadly speaking, two methods of obtaining it. The older is by pressure, whereby the cells are broken, and the juice squeezed out; and for this purpose heavy roller mills, combined (or not) with disintegrators, are in use. The other depends on the fact that a solution of a crystallisable body, separated from another liquid by a thin membrane, is gradually deprived by that liquid of a part of the dissolved substance. That is, when cells containing cane juice are immersed in water, some of the sugar passes through the cell wall into the water, and by renewing the water systematically, the greater part of the sugar can be so extracted.

BEET.

The other great source of commercial sugar, the beet-root (*Beta vulgaris*), is a hardy biennial indigenous to Southern Europe, but cultivated with success in the United States, Canada, and New Zealand, and, as far as climatic conditions are concerned, in this country also. Its production here has always been extremely limited, although, about 22 years ago, Mr. Duncan, a London sugar refiner, tried to make sugar-beet production a success at Lavenham, in Suffolk. He there established a factory for extracting the juice from the beet, which juice, when brought to charge and concentrated, was sent for refining to his London factory. The growth of beet was stimulated by the offer of prizes to the most successful growers, but owing to circumstances arising out of the bounty system, the local factory was closed in 1874, and afterwards the London refinery was shut up.

The general characteristics of good beets are regular pear-shape, smooth skin, firm flesh, uniform structure, clean, sugary flavour, high specific gravity, and a weight seldom exceeding 1½—2½ lbs.

Perhaps the most esteemed of the many varieties are "white Silesian," "green neck," "red neck" (a favourite in France), and the "grey neck," all producing from 2½ to 3½ tons of sugar per acre. Internally, the beet is built up of concentric rings of small cells containing sugar and other bodies (principally salts of potash) in a watery solution. The sugar itself is identical with cane sugar, but the larger proportion of potash salts causes more difficulty to the refiner, and commercial samples are not quite so sweet as those from the cane. Beets contain no uncrystallisable sugar; molasses are produced by unavoidable changes in the course of manufacture.

Manure must be applied to beet soils with great caution, and only in the early autumn. Neglect often brings about big watery roots abounding in nitrogenous matters. Sowing should take place at the beginning or middle of April; if earlier, frost is apt to nip the young plant; if later, it runs a risk of not ripening. If the autumn is dry the roots may be left in the ground while the juice increases in gravity, but of all things frost must be avoided. After taking up, a good plan is to cover loosely in the field for two days, then trim and stack. The roots are well cleaned, sliced or rasped, and pressed or macerated much in the same manner as the cane is treated.

The Table IV. in p. 981 is of special interest, as it shows the steady increase in the quantity of beet sugar produced from the year 1873 to 1887, and the corresponding diminution of cane sugar. No doubt the increased consumption of refined sugar has accomplished this result; for while the beet cannot, on account of its strong objectionable flavour, be consumed in the raw state, still its freedom from molasses or uncrystallisable sugar causes it to be very much in demand for the use of the refiner, and at the present time there is very little refined sugar made exclusively from cane without any admixture of beet. The loaf sugar either of British or foreign manufacture now on the market will, when warmed in the hand, speedily reveal its origin, and however crystalline it may be, or faultless the colour, refined sugar containing beet will never lose entirely its offensively-objectionable smell and flavour. To the refiner, however, it possesses, as before stated, invaluable qualities, and on this ground its consumption is not likely to decrease, because refined sugar is steadily coming into more general use, even in those countries where raw cane sugar can be easily obtained.

TABLE IV.—Production of Sugar.

Year.	Beet.		Cane.				Total Tons.
			British.		Foreign.		
	Tons.	Per cent. of total.	Tons.	Per cent. of total.	Tons.	Per cent. of total.	
1873......	1,110,166	38	362,729	12	1,478,257	50	2,951,152
1874......	1,054,055	38	334,164	12	1 377,599	50	2,765,818
1875......	1,317,623	43	332,878	11	1,412,606	46	3,063,107
1876......	1,059,281	39	343,570	12	1,337,619	49	2,740,470
1877......	1,101,141	40	407,195	15	1,263,918	45	2,772,254
1878... .	1,420,827	45	393,536	13	1,305,207	42	3,119,570
1879......	1,574,153	45	409,482	12	1,534,624	43	3,518,259
1880.....	1,403 929	43	371,486	11	1,503,444	46	3,278,859
1881......	1,749,545	48	386,032	11	1,474.444	41	3,610,021
1882......	1,783,200	47	498,396	13	1,517,688	40	3,799,284
1883......	2,146,534	50	494,834	12	1,609,238	38	4,250,606
1884......	2,360,314	48	608,037	12	1,939,494	40	4,907,845
1885......	2,545,889	50	571,774	11	2,020,873	39	5,138,536
1886......	2,137,351	44	545,030	11	2,157,820	45	4,840,201
1887......	2,728,810	49	613.347	11	2,192,388	40	5,534,545

Sugar of Commerce.

The sugar of commerce can be divided into two large classes—Raw and Refined.

Each class contains many varieties and many shades of quality, but the term raw sugar is generally applied to sugar of whatever degree of purity manufactured on the plantation or place of production, and refined sugar embraces the large and comprehensive class of sugar re-manufactured from raw sugar at refineries or central factories.

At first sight it may appear to be a mistake to export from the sugar plantation sugar containing many impurities, and which has to be re-manufactured into the refined sugar of commerce, but a few moments' consideration will show why it has been necessary to submit many kinds of raw sugar to a further process of purification before being sent into actual consumption. To make sugar of good quality expensive machinery is required, and it is necessary to have an ample supply of fuel and water. The machinery now in use on sugar plantations is generally obtained from this country, and it has to be repaired and kept in working condition generally by English workmen. Fuel and water are usually very scarce, and coal, when used, has to be sent from Europe. Capital also generally commands a much higher rate of interest than in this country, so on these general grounds, as well as on special ones, the refining industry first found a home in Great Britain, France, the Netherlands, and Germany, but, from causes to be afterwards enumerated, the refiners' occupation in London, Bristol, and other large centres has been for many years a failing one, and France, Germany, and the Netherlands have appropriated the manufacture of loaf sugar, and can sell it on the English market cheaper than it can be produced at home.

On a sugar plantation the cane juice is only converted into sugar at a certain period of the year, when the canes are ripe; whilst at a refinery raw material can be obtained for continuous work, and the combination of capital, machinery, skill, and production on a large scale, enables sugar to be produced at a cheap rate, and of first and uniform quality.

The manufacture of sugar is one requiring considerable chemical knowledge, and at the plantation much sugar is lost through not having the proper appliances and apparatus at hand. In nature's laboratory the juices of the cane are changed, by an active chemical principle in the cane itself, into a sweet substance which is essentially a weak solution of cane sugar. Given certain conditions of temperature and ripeness of cane, this cane sugar is gradually converted into another description of sugar—glucose, which differs in chemical composition from cane sugar, possesses very different characters, and not only will not crystallise as cane sugar does, but has the property of preventing by its presence the crystallisation of a quantity of cane sugar at least as great in amount as itself.

The sugar planter's art is not confined to growing the canes, and cutting them for extracting the sugar when the maximum quantity is present. The most responsible work comes in when the canes are removed to the sugar-house for crushing and extracting the juice; and it is here that the best of skill is required to obtain from the juice the maximum quantity of cane sugar in the best marketable condition. The nitrogenous ferment is in the juice, and the temperature and density of the juice are in favour of a rapid conversion of the cane sugar present into glucose. The juice is distinctly acid, and the chemist is aware that by acids it is very easy to convert cane sugar into glucose. On a commercial scale this process of making glucose would not pay, because glucose can be prepared with ease from cheaper materials than cane sugar; and when touching upon the use of sugar in breweries, glucose sugar will demand fuller treatment than is here necessary when considering it simply as an impurity in cane juice.

The first operation in the sugar-curing house is to add to the freshly-crushed juice lime or some other alkali to neutralise the acid of the juice, and to suspend the action of the ferment. The juice is then boiled in different ways, to coagulate the albuminous matter which contains the ferment, to clarify the juice, and to drive off superfluous water. This boiling is generally done over an open fire, and the same effect occurs as when for domestic purposes we boil a clear cane syrup. The sugar coming in contact with the bottom of the vessel is more or less burned, a substance called caramel is formed, and a quantity of glucose is produced at the expense of the cane sugar.

The appearance and composition of the common descriptions of commercial sugar show how crude the operations are at some of the factories or plantations, and from the finished article it is evident what advantages would be gained by employing better machinery, and working on a more scientific basis.

Muscovados and others of their class are light in colour, clean, with a good crystal, and from their sweetness and smallness of grain are popular favourites for cooking and other domestic purposes.

Three descriptions of sugar before us, viz., "Barbadoes," "White Clayed," and "Demerara," are fairly representative specimens of the raw sugar that is imported from our colonies and other tropical countries.

Barbadoes.—This sample is one which has been very fairly prepared with the commonest (crudest) appliances in use. It has been boiled down over an open fire to the crystallising point, the syrup has then been run into casks for crystallisation, and when the crystals have formed, the casks are turned bung downwards for the uncrystallised portion—the molasses—to drain out. The molasses contains a large quantity of crystallisable sugar, and it is boiled down to the crystallising point to obtain a further crop of crystals.

As the sugar in the cask is not by any means free from molasses, it follows that, when the cask is bunged up and exported, the molasses will settle down in the lower part of the hogshead, and this mixture of crystallised sugar and molasses forms the dark nodules seen in the sample, and is known in the trade by the designation of "Foots." When buying sugar of this description it is of the first importance to the buyer to know whether the quantity of "foots" is great or small, and if present in excessive quantity it is dangerous to buy such sugar for domestic use. When a duty was charged on sugar, a core of the sugar was taken out from one side of the cask to the other, so as to get a fair average sample of the whole bulk for an equitable assessment. For commercial purposes it is equally important to obtain a fair sample, but this is very difficult to do, especially as all the casks in one consignment even will not be alike in this respect, and it is therefore very necessary to avoid buying such sugar of too low a grade. The unsatisfactory character of sugar so made, and the low price it commanded in foreign markets, led many of the sugar planters to adopt methods for purifying the crystals from the molasses adhering to them.

Clayed Sugar.—A process introduced by the Spanish sugar growers was a marked improvement on the previous one. In this process the syrup was made to run into "forms," which in outline resembled a sugar-loaf turned upside down, and had a hole at the apex, which could be kept shut or open at pleasure. When the crystallisation of the syrup had taken place, the hole was opened for the discharge of the molasses. This discharge was hastened by spreading over the broad end a layer of wet clay. The moisture steadily left the clay, percolated between the crystals towards the narrow point, and washed out the molasses. The process improved the appearance of the sugar, and gave it greater uniformity of composition, but the crystals suffered from the treatment, being made smaller through the solvent action of the water. When the operation was complete and the crystals dry, they were emptied from the forms and put into casks for exportation. This claying process is still in general use, for although there is considerable loss by the treatment, the complexion and uniformity of quality command a price which more than covers the increased cost of manufacture.

A small sample from the original package will fairly represent the bulk, and the distributor is thus spared the expense of thoroughly mixing together the heavy and dry sugar present in the hogshead previously mentioned, and putting the two kinds through a grinding machine to ensure uniformity in colour and grain.

Demerara Sugar.—The sugar with a large crystal, known in the trade as Demerara, requires special treatment for its production. Its special characteristics are a golden colour or bloom, a well-defined crystal, and a fine flavour. Very frequently it commands as high a price as loaf sugar, and at all times it fetches a far higher price than the small grained raw sugar of commerce.

Special care is taken that the canes crushed shall be sound; all rotten, diseased, or sour canes being carefully separated. The canes themselves are carefully assorted into different sizes, so that the layers put into the crushing mill shall be of the same thickness, and thereby subjected to an equal and uniform pressure.

TABLE V.—Composition of Different Qualities of Cane Juice.

Specific Gravity.	Weight per cent. of			
	Albumen.	Ash.	Sugar.	
			Crystallisable.	Uncrystallisable.
1·031	0·71	0·48	3·40	1·30
1·043	0·55	0·30	8·00	2·50
1·063	0·29	0·18	12·40	1·60
1·070	0·37	0·32	16·76	0·24
1·071	0·37	0·44	17·30	0·20
1·072	0·48	0·36	16·70	0·30

From this it appears that the juice thus obtained contain from 8 to 17 per cent. of cane sugar, ·20 to 2·5 per cent. of glucose, and it has a strong acid reaction. The acids present are both organic and mineral, the principal mineral acid being phosphoric. There is a distinct relation between the amount of acid and glucose present in the juice; the greater the acid, the more glucose, and, consequently, the sounder the cane the better the juice, and the larger the proportion of cane sugar.

TABLE VI.—Proportion of Ash to Cane Sugar in Ten Samples of Juice.

Cane Juice.	Beet Juice.
1 to 12·6	1 to 15·7
1 ,, 19·9	1 ,, 16·3
1 ,, 21·2	1 ,, 16·8
1 ,, 26·6	1 ,, 17·6
1 ,, 39·3	1 ,, 17·6
1 ,, 46·3	1 ,, 17·7
1 ,, 52·3	1 ,, 17·8
1 ,, 53·8	1 ,, 18·2
1 ,, 65·0	1 ,, 18·4
1 ,, 68·8	1 ,, 21·2
Average 1 ,, 40·5	Average 1 ,, 17·7

The juice having been extracted, the next operation is to prevent its passing into fermentation or acidity. It is conveyed into a close wooden tank, into which it is delivered in spray, and this spray is acted on by a stream of sulphurous acid gas, which enters the vessel from the bottom. This gas effects two objects, it prevents fermentation, and also bleaches the juice, so that when it leaves the vat the juice is brighter and clearer than when it entered it. The chemical changes which have taken place in the juice are that it is more acid from being impregnated with sulphurous acid, and the glucose has been slightly increased at the expense of the cane sugar.

Clarification is the next process in the refining operation, and this is effected by first adding suitable quantities of milk of lime, *i.e.*, till the juice has only a slightly acid reaction, as excess of alkali immediately darkens the syrup; more recently, acid lime phosphate has been employed in combination with milk of lime, with very satisfactory results. The boiling of the syrup so treated brings about rapid clarification, the flocculent matter, on standing, falls to the bottom, the clear syrup under the scum is carefully drawn off, the scum itself is pressed in properly constructed filters, and the clear juice obtained from it added to the bulk of the syrup. This clear juice is a second time clarified, and then boiled and concentrated for crystallisation.

The evaporation is carried out in vacuum pans, the boiling point of the syrup being reduced, so that at no time it exceeds about 160° F. The boiling must not be too violent, or the crystals will be small, but if the evaporation is too slow, the sugar obtained is not of a satisfactory quality. The crystallisation proceeds rapidly, and when the critical point is reached for drawing off the sugar, or "striking," as it is technically called, it is run into moveable vats holding about 6,000 lbs. each. Before it has cooled it is put into a centrifugal machine with a little water, if necessary, which has the effect of clearing the crystals. When this operation is complete, the crystals of sugar remaining in the machine are carefully removed, examined, and packed for market.

The syrup separated by the centrifugal machine from the crystals of sugar contains a large proportion of cane sugar and the whole of the glucose. This syrup is usually diluted with water, made alkaline with lime-water, and then slowly boiled, and afterwards run into crystallising vats. In two or three weeks crystallisation is complete, and the crystals of sugar are then separated from the syrup by the centrifugal machine. These crystals of sugar are of small grain and are light in colour. The syrup separated may be treated as before, but the price of sugar generally regulates this operation, and if the market price be low the syrup may be used for rum-making.

It has been said that the manufacturer of Muscovado sugar makes good rum at the expense of the sugar, and that the maker of Demerara crystals produces good sugar at the expense of the rum. The Jamaica sugar growers make a very poor sugar, whilst the rum produced in the island is the best in the world, and the converse is true of the Demerara planter. His sugar is good, but the Demerara rum is of very poor quality, and fetches a very low price. The chemicals employed for purifying and clarifying juice must have a bad effect on the syrup residue, and the materials used for making rum are too impure to compare favourably with syrup residues obtained by the primitive methods generally in use in Jamaica. It may be taken as a fact that the rum made on the plantations which are famous for their special qualities of sugar is poor, and that, generally speaking, of late years, owing to improvements in sugar production, the rum which is sent to market is rapidly deteriorating in quality.

A sample of Demerara rum was sent to me in 1888, for examination, by an old friend who occupies the position of Chief Commissary of British Guiana. Its fault was too apparent, on account of its offensiveness of smell and taste, and the quality was too bad to allow it to be reckoned commercial rum. An analysis of the sample showed that organic sulphur compounds were present, and they were no doubt derived from the sulphites and other chemicals of a like kind used for bleaching the sugar. It was evident that there could be no improvement in the quality of the rum unless the chemicals were abandoned, or the objectionable sulphur compounds kept out of the spirit. The chemicals could not be put on one side, and consequently the second alternative—the arrestment of the sulphur compounds—only presented itself for solving the problem. The Commissary has devised an apparatus containing layers of charcoal, for passing through it the spirit vapour at a high temperature. The result has been that the sulphur compounds were thus decomposed, the sulphur left behind with the charcoal, and the spirit so much improved, that he is able to report that the rum from the distillery supplying the bad rum, "which was formerly sold with difficulty at low rates in London, very recently commanded the top price of the London market." This practical method of purification of rum made from chemically-treated syrups must be of very great value to the Demerara sugar-makers, and it may be made the means of bridging over the difference which now exists in the commercial value of the rums known in the trade as Jamaica and Demerara.

The demand for Demerara sugar has tempted the home refiner to manufacture an article known in the trade as "Imitation Demerara." One or two of these specimens are of very fair quality, of good grain and colour, and made almost entirely from cane sugar. But there are others having an artificial bloom, and an offensive smell, showing that they are made largely from beet, and by chemical tests the colour is proved to be artificial. The public should be on their guard against buying this objectionable counterfeit, for its use will certainly bring Demerara sugar into disrepute, and will make the consumer suspicious of its quality. It has been contended, in defence of this home product, that Demerara sugar when imported contains a large amount of impurities, that in the interests of the consumer it should be refined and made more pure by the treatment. The contention is ingenious but not true, for Demerara sugar does not contain 1 per cent. of foreign matter, and is essentially suited for direct consumption. The sugar has been imitated because it fetches a high price in the market, and as it can only be made at a certain time of the year the supply is irregular. Scarcity of supply hardens the price, and there is no doubt that the quality of the sugar and the irregularity of the supply have tempted refiners to imitate the sugar, and to obtain a price for the refined imitation which it would not otherwise command. Legitimate competition always benefits the consumer, but in this instance the consumer may find to his cost that "Imitation Demerara" is comparatively dear, and some specimens of it are certainly very objectionable to smell and taste.

EAST INDIA SUGAR.

Almost every part of India and Burmah is suited to the cultivation, the only drawback being the dependence on irrigation for moisture at certain seasons. Notwithstanding, the area under canes is continually increasing, although the modes of growth, expression of juice and preparation, remain practically what they were in primitive times. "Refining" in the modern sense is unknown, except in the few European establishments, religious prejudice precluding the use of modern methods in native factories. The product of the European refineries is regarded by the native population as unclean, being, as they think, contaminated with bones and blood, on account of animal charcoal having been used for decolourising the cane syrup. The one innovation is the adoption of improved mills.

In other cane countries 30 to 36 tons of cane per acre are common. The half is hardly reached in India, so great is the neglect of proper selection of seed. Too rapid rotation of crops, absence of manures containing phosphates and mineral matters, late and irregular planting, careless sowing, deficient irrigation, and bad cutting, all bring down the yield.

In the West Indies 70 to 85 per cent. of the weight of cane is expressed; in India 50 to 55 per cent.; and whilst in the former the weight of dry sugar on each acre is three times that of molasses, in the latter the quantities are practically reversed, as there is twice as much molasses as dry sugar.

The juice is dealt with in two ways:—(1) Boiled to a dry consistency, when it is called "*shakur*" if clarified—"*goor*" if unclarified. (2) Boiled to semi-liquid, "*rab*;" pressed in bag with the feet, strained, and kneaded by trampling in the sun, this becomes the "*kacha chini*" of internal commerce.

The only further developments of semi-refined sugars in native hands are effected by boiling in milk and straining.

Exported to Europe, the raw sugars are valueless for refining, and can only be used by brewers.

"Rab" per acre = 4,500 lbs.
"Goor" ,, = 4,000 lbs.

Average out-turn of dry sugar (Muscovado):—

Barbadoes = 4 tons per acre.
Singapore = 3 tons, 4 cwt.——2 tons, 2 cwt.
Vicinity of Calcutta = 1 ton, 3 cwt.

REFINED SUGAR.

The sugar refiner establishes his refinery where fuel and water can be obtained cheaply and in plentiful supply, and at a seaport town connected with those countries from which raw sugar is imported in large quantities. Thus Bristol, which at one time had the command of the West India markets, also possessed a thriving sugar refining trade. As Liverpool and Greenock withdrew the West India trade from Bristol, so the refining trade left the banks of the Avon, and was established at Liverpool and Greenock. London had at the same time a very prosperous refining industry, but the foreign bounty system ruined the London refiners or compelled them to retire from business, and concurrently the Liverpool and Greenock refiners suffered, but not to a like extent, on account of being more largely engaged in the manufacture of soft sugars, which were not imported on bounty like refined loaf sugar.

During the last ten years, the Greenock system of manufacture has been successfully established on the banks of the Thames, and loaf sugar, now known in the trade as "cubes," has superseded the old loaf sugar, and enabled the makers of it to reap a profit, and to a large extent revolutionise their own branch of trade. It has been stated that in 1888 there were in London five refineries at work, turning out 200,000 tons of hard and soft sugars; in Liverpool ten refineries, turning out 258,000 tons; in Greenock seven refineries, turning out 233,000 tons; in Bristol two refineries, turning out 33,000 tons; in other places two refineries, turning out 15,000 tons; making a total of 739,000 tons.

The refiner, having the command of a large and varied selection of cane and beet sugar, chooses for refining that most suitable to his special requirements, and in this way has, as before stated, a direct advantage over the owner of a sugar plantation who is tied down to his own produce, and can only work for a portion of the year. Continuous work and the choice of materials enable the refiner to turn out refined soft sugar at a lower price than raw sugar of the same colour and grain, and during the last few years sugar known as "refiners' pieces" has come steadily into favour with grocers, on account of its uniformity of quality and the convenient size and weight of the bags in which it is sent from the refinery, and these different descriptions of refiners' produce with loaf sugar in cubes, packed in 1 cwt. and 2 cwt. boxes, have for the present given new life to our refining industry, and enabled a few manufacturers to make profits instead of losses.

Some of these "pieces" whose complexion is very fair have a very unpleasant odour. In fact, it is the rank smell of some of them which unfits them for use as distinct substitutes for common raw cane sugar, because it matters not how dark and unsightly the raw sugar is, it has a smell and flavour distinctly pleasant to nose and taste.

Some idea of the impurities to be removed by the refiner may be gained when it is considered that 100 parts of raw sugar ash contain practically:—

	Cane.	Beet.
Potash	28·79	34·19
Soda	·87	11·12
Lime	8·83	3·60
Magnesia	2·73	·16
Oxide of iron	6·90	·28
Sulphuric anhydride	43·65	48·85
Silica	8·29	1·78

after the usual treatment with sulphuric acid. In addition, there are glucoses, low sugars, and other organic matter present.

The operations of the refiner consist in remelting the raw sugar, carefully filtering the syrup from its impurities, clarifying it by passage through animal charcoal, boiling down the decolorised syrup at a low temperature in the vacuum pan till the syrup is ready to crystallise, and then crystallising this syrup in the way to produce the exact description of sugar he desires. The sugar when at the crystallising point is technically called the "masse-cuite;" and if loaf sugar is required the mass is run into moulds of suitable size, and if granulated or soft sugar is wanted, the syrup, when of proper consistency, is put into a centrifugal machine, by the action of which the syrup is driven out from the crystals. This syrup is again boiled and condensed till it reaches the crystallising point, when it is transferred to the centrifugal machine and treated as before.

Moulded cube sugar is made in the form of slabs or sticks, which are afterwards cut into cubes or tablets. The inventions for this purpose are extremely numerous, the chief being perhaps those of Langen, Tietz, Duncan and Newlands, and Walker and Patterson—all in operation on a manufacturing scale. The masse-cuite is cast, so to speak, in moulds, liquored, and dried, either by revolution in the centrifugal or by stoving.

An inferior class of cube sugar is sometimes obtained by pressing the centrifugal granular sugar in moulds of required shape; usually cubes or sticks of sugar (which can easily be cut into cubes) are produced.

A sugar much in favour in the United States is the granulated—which must not be confounded with the so-called German or Austrian granulated, this being mostly raw beet sugar washed with steam. It is practically free from moisture and impurity, is easily dissolved, and does not lose weight or colour on keeping. It is refined in the ordinary way, and boiled to a small sharp grain like that of loaf, and washed as usual in the centrifugal. On leaving it contains 1 to 1½ per cent. of moisture, and in this state it is delivered to the granulating machine, in which it is dropped in a continuous shower on a hot cylinder, and gradually worked to the end, and then sifted and sorted automatically into grades ready for packing. Hersey's machine will granulate 6,000 lbs. per hour.

Many special processes are in use for the removal of such impurities as resist the general mode of treatment just described. Thus, the "alum process," for potash salts (Duncan and Newlands), consists essentially, in the addition to the cold syrup of raw sugar, of enough sulphate of alumina to precipitate the whole of the potash, neutralisation being effected by lime. Oxalic acid has been proposed by Gill for the same purpose. Strontium, which combines with sugar, is sometimes employed, but not at present to any great extent.

Favourites in some refineries are Easte's

"Chloride of Sulphur," and Boivin's "Sucrate of Lime" processes; in this country their use is limited, if, indeed, they are employed at all.

SUGAR ANALYSIS.

Sugar analysis is a very wide subject, which cannot in the space at our disposal be adequately considered; but as the ordinary commercial analysis of sugar is mainly confined to the determination of its value to the sugar refiner, it will be interesting to notice how commercial analysis is usually conducted.

The determinations usually made are:—(1) The moisture; (2) the cane sugar; (3) the ash; (4) the uncrystallisable sugar; (5) the other organic matters; (6) the insoluble constituents.

The organic matters referred to in No. 5 are usually classed together, since their separate estimation would entail lengthy and elaborate processes without any corresponding advantages to compensate for the labour. In this group are betaine (an alkaloid present in beet juice), cellulose, albumen, gum, fat, caramel, and wax. The insoluble substances present are generally accidental impurities, and consist chiefly of sand, clay, and vegetable fibre.

For the estimation of the cane sugar the polariscope is generally used, in fact, it would be impracticable to conduct the large number of analyses required by the purchaser and refiner of sugar by chemical manipulation only.

On account of the importance of this instrument to the sugar refiner it demands a passing remark respecting its construction and application to sugar analysis.

A ray of ordinary light is propagated by vibration at right angles in all directions to the path of the ray, but by suitable means—such as passing the ray through a crystal of Iceland spar—all these vibrations can be reduced to vibrations simply in one plane. A ray so transmitted is said to be polarised.

Cane sugar, in common with some other bodies, has the power of twisting or rotating this plane when the polarised ray of light is made to pass through a solution of it, the amount of twist being regulated by the quantity of sugar in the solution through which it is made to pass.

The polariscope is merely a convenient practical instrument for utilising all these properties, and is constructed to produce a polarised ray, then, by means of the solution to be tested, rotating its plane, and finally, by properly-constructed scales, to measure the amount of twist caused by the solution through which the ray has passed. The strength of the sugar solution and the length of the column of liquid through which the ray passes being known, there is no difficulty in working out by a simple calculation the quantity of cane sugar present in the sample.

In the ordinary commercial analysis of sugar, however, there are certain substances present which interfere with this determination. The uncrystallisable sugar twists the ray in an opposite direction, and therefore the quantity of uncrystallisable sugar must be determined separately. Again, the salts present in the sugar have a prejudicial effect on the crystallisation of the cane sugar, and those present in beet sugar are worse than those in that made from the sugar-cane. It will therefore be apparent that in setting out the value to the refiner of a commercial sugar, certain modifications of the actual results obtained have to be made to cause the assumed yield practically to coincide with the actual quantity produced by the refiner.

The following example will show how this is done in practice. A sample of beet sugar was found to give 92 per cent. of crystallisable sugar, 1¼ per cent. of uncrystallisable sugar, and 1 per cent. of ash. The 1 per cent. of ash would in the case of beet sugar prevent five times its weight of crystallisable sugar from crystallising in the refining process, and in the case of cane sugar three times its weight. The result of the analysis would thus be given:—

Crystallisable sugar..................		92 per cent.
Deduct uncrystallisable sugar	1¼ per cent.	
,, ash 1 × 5 ...... =	5 ,,	
Total deduction		6¼ ,,
Value to refiner		85¾ ,,

Even in a refinery many parcels of sugar cannot be estimated as above described, their colour, composition, or other peculiarity requiring special treatment.

Sugar for brewers' use, and for general analysis, has to be examined differently, but as the methods in use are somewhat elaborate, and would require special description, it is not necessary to refer to them in detail in a popular lecture. Those who wish to make the subject a specialty must study works devoted to the analysis of commercial materials, which contain not only methods of analysis, but also point out the difficulties which arise in conducting general sugar analysis, and the best means to evade or overcome them.

SUGAR DUTIES IMPOSED.

The importation of sugar was sufficiently large in the time of James I. to attract the attention of the then Chancellor of the Exchequer, and a duty was imposed upon it. The greater part of our supplies of sugar were at first obtained from the British West Indies, the agreement between the colonies and the mother country being that the colonies must send their sugar here exclusively, and the mother country would, in return, give them a monopoly. British sentiment was also aroused against the importation of sugar produced by slave labour, and consequently the sugar market was very unsettled from these causes. It was seen that no restrictions, however severe, could keep out slave-grown sugar, or limit our supplies to what was grown in our own colonies. The agitation only increased the price of sugar to the consumer, and stimulated artifice in defeating the regulations laid down for the importation of sugar. At length common sense overcame sentiment, and though no efforts for the abolition of slavery were relaxed, yet it was seen that the only practical course open was to allow the importation of sugar from any country. Healthy competition soon changed the source of our sugar supplies, and in this connection the following comparison may be interesting.

TABLE VII.—IMPORTS OF SUGAR.—WEST INDIES COMPARED WITH TOTAL.

Year.	West Indies.		Total.
	Practically all raw.	Per cent. of Total.	
Average.	Cwts.		Cwts.
1846–50	2,716,800	38·9	6,980,000
1851–55	3,137,000	38·8	8,074,000
1856–60	3,151,000	35·4	8,902,000
1861–64	3,611,000	33·2	10,851,000
1872–75	3,970,677	23·3	16,998,437
1876–80	4,076,306	20 9	19,487,004
1881–85	3,210,066	13·8	23,265,981
1886–89	2,033,201	8·2	24,702,329

From 1801–1810 the average was 91·1 per cent. of the total sugar imported.

This change of policy has had a disastrous effect on our sugar-producing colonies. Protected at first by differential duties, they depended on the favour thus shown for their profits, and with the abolition of slavery they found themselves obliged to pay much more for labour than their competitors. Finally, the equalisation of duties took away the last vestige of protection, and the colonial sugar industry has, as a matter of course, made little headway, it being indeed on the road to decay, and the sugar plantations have become of little value. The change of policy, although seriously injuring our colonial industry, has wonderfully stimulated the consumption of sugar through the reduction in price, and we have lately had to go to continental sources for a large proportion of our supplies.

In the reign of Queen Anne the duty on sugar of all kinds was 3s. 5d. a cwt.; in 1780 it was 6s. 8d., in 1787 it was 12s. 4d., and in 1791 it was raised to 15s. Increased war expenditure heavily taxed the resources of the Chancellor of the Exchequer, and without giving much consideration to the question as to whether sugar could successfully carry a larger duty, he raised the duty in 1797 to 17s. 6d., in 1799 to 20s., and in 1806 to 30s. From the action of the Legislature it can be seen that the last impost was due rather to the action of persons driven to their wits' ends for money than of cool-headed statesmen, for it was enacted that if, during a certain period named, the price of sugar in bond should fall below 49s. a cwt., there should be a rebate of duty of 1s. a cwt.; if below 48s., 2s.; and if below 47s., 3s. a cwt. might be remitted.

In 1826, the duty on West India sugar was made 27s., without regard to price. In 1830, the duty on West India and Mauritius sugar was reduced to 24s., while East India sugar was as high as 32s. The following Table will be of value in studying the variations of the sugar duty. In 1836, the duties on these sugars were equalised at 24s., but sugar from other countries continued to be charged with duty at 63s. a cwt. This great difference of rates was intended to act as a prohibition on the importation of what may be justly termed foreign-grown sugar, and the effect of this difference was shown in the great variation in price in bond of our colonial sugar and its competitors. It must follow that such a protective duty would cause the colonial sugar grower to place a fancy price on the sugar he made, so that the difference between the two rates of duty might appear a little less than it really was. And this increase of price was so apparent that in 1844 a colonial sugar

TABLE VIII.—DUTIES FROM 1837 TO 1854, WITH QUANTITIES OF HOME-GROWN SUGAR CHARGED.

<table>
<tr><th rowspan="3">Year.</th><th colspan="2">Home-grown.</th><th colspan="9">Customs Duties.</th></tr>
<tr><th rowspan="2">Cwts. charged.</th><th rowspan="2">Excise duty.</th><th colspan="2" rowspan="2">Colonial.</th><th colspan="4">East Indian.</th><th colspan="3" rowspan="2">Foreign.</th></tr>
<tr><th colspan="2">Any British Possession within East India Company's Charter in which foreign sugar is prohibited.</th><th colspan="2">Any other British Possession within those limits, and thence imported.</th></tr>
<tr><td>1837</td><td>—</td><td>—</td><td colspan="2">£1 4 0</td><td colspan="2">£1 4 0</td><td colspan="2">£1 12 0</td><td colspan="3">£3 3 0</td></tr>
<tr><td>1838</td><td>129</td><td>£1 4 0</td><td colspan="2">,,</td><td colspan="2">,,</td><td colspan="2">,,</td><td colspan="3">,,</td></tr>
<tr><td>1839</td><td>10</td><td>,,</td><td colspan="2">,,</td><td colspan="2">,,</td><td colspan="2">,,</td><td colspan="3">,,</td></tr>
<tr><td>1840</td><td>10¼</td><td>1 4 0 and 5 %</td><td colspan="2">1 5 $2\frac{1}{3}$</td><td colspan="2">1 5 $2\frac{1}{3}$</td><td colspan="2">1 13 $7\frac{1}{3}$</td><td colspan="3">3 6 $1\frac{3}{4}$</td></tr>
<tr><td>1841</td><td>2,355</td><td>,,</td><td colspan="2">,,</td><td colspan="2">,,</td><td colspan="2">,,</td><td colspan="3">,,</td></tr>
<tr><td>1842</td><td>3,477</td><td>,,</td><td colspan="2">,,</td><td colspan="2">,,</td><td colspan="2">,,</td><td colspan="3">,,</td></tr>
<tr><td>1843</td><td>3,843</td><td>,,</td><td colspan="2">,,</td><td colspan="2">,,</td><td colspan="2">,,</td><td colspan="3">,,</td></tr>
<tr><td></td><td></td><td></td><td colspan="2"></td><td colspan="2"></td><td colspan="2"></td><td colspan="2">Any foreign country (not produced by slave labour).</td><td>Other foreign sugar.</td></tr>
<tr><td>1844</td><td>5,597</td><td>,,</td><td colspan="2">,,</td><td colspan="2">,,</td><td colspan="2">,,</td><td colspan="2">£1 15 $1\frac{1}{3}$</td><td>£3 6 1</td></tr>
<tr><td></td><td></td><td></td><td colspan="8">Equal or Not Equal to White Clayed.</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Equal.</td><td>Not equal.</td><td>Equal.</td><td>Not equal.</td><td>Equal.</td><td>Not equal.</td><td>Equal.</td><td>Not equal.</td><td></td></tr>
<tr><td>1845</td><td>4,371</td><td>14/-</td><td>16/4</td><td>14/-</td><td>16/4</td><td>14/-</td><td>£1 1 9</td><td>18/8</td><td>£1 8 0</td><td>£1 3 4</td><td>3 3 0</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="3">Any foreign country.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">If imported direct.</td><td rowspan="3">Otherwise imported.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Equal or not equal to white clayed.</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Equal.</td><td>Not equal.</td></tr>
<tr><td>1846</td><td>3,585</td><td>,,</td><td>,,</td><td>,,</td><td>,,</td><td>,,</td><td>1 0 5</td><td>17/6</td><td>£1 4 6</td><td>£1 1 0</td><td>£2 2 0</td></tr>
<tr><td>1847</td><td>177</td><td>,,</td><td>,,</td><td>,,</td><td>,,</td><td>,,</td><td>0 19 10</td><td>17/-</td><td>1 3 4</td><td>1 0 0</td><td>,,</td></tr>
<tr><td>1848</td><td>nil.</td><td>,,</td><td colspan="9" rowspan="6">From 1848 to 1854 the duties were progressively reduced.</td></tr>
<tr><td>1849</td><td>,,</td><td>,,</td></tr>
<tr><td>1850</td><td>,,</td><td>11/-</td></tr>
<tr><td>1851</td><td>6</td><td>10/-</td></tr>
<tr><td>1852</td><td>347</td><td>,,</td></tr>
<tr><td>1853</td><td>1,538</td><td>,,</td></tr>
</table>

sold in bond at 33s. was of no better quality than its competitor at 17s. 6d. a cwt.

Such an indirect tax on the consumer could not long be defended, and as at this juncture the quantity of sugar imported from our colonies largely diminished, it was necessary, in the interest of the user of sugar, to make a change in the rates of duty to meet the abnormal condition of the sugar market.

In 1845, the duty on British colonial sugar was reduced to 14s. per cwt., a special rate of 23s. 4d. per cwt. was imposed on free labour sugar, and slave labour sugar remained at 63s.

At this period of our history the principles of free trade were not only widely preached, but took hold of public opinion. One result was the abolition of the Corn Laws, and in 1846 the Act 9 and 10 Vict. c. 63 equalised the duty on all descriptions of foreign sugars, whether produced by free or slave labour. The full equalisation of the sugar duties did not come into force until July 5, 1854.

TABLE IX. — TABLE OF DUTIES FROM THEIR EQUALISATION IN 1855 TO THEIR ABOLITION IN 1875, WITH QUANTITIES OF HOME-GROWN SUGAR CHARGED.

Year. Ended 31st March.	Cwts. of home-grown sugar charged.	Rates of duty.					
		Refined.	White clayed.	Yellow Muscovado.	Brown.		Molasses.
1855.	1,217	16/-	14/-	12/-	11/-		4/6
1856.	657	£1	17/6	15/-	13/-		5/4
1857.	104	,,	,,	,,	,,		,,
1858 to 1862	nil.	,,	,,	,,	,,		,,
1863.	140	,,	,,	,,	,,		,,
1864.	nil.	,,	,,	,,	,,		,,
						Not equal to brown.	
1865.	1,064	12/10	11/8	10/6	9/4	8/2	3/6
1866.	590	,,	,,	,,	,,	,,	,,
1867.	18	,,	,,	,,	,,	,,	,,
			Not equal to refined.				
			1st class.	2nd class.	3rd class.	4th class.	
1868.	2,940	12/-	11/3	10/6	9/7	8/-	,,
1869.	17,443	,,	,,	,,	,,	,,	,,
1870.	28,710	,,	,,	,,	,,	,,	,,
1871.	29,721	6/-	5/8	5/3	4/9	4/-	1/9
1872.	34,965	,,	,,	,,	,,	,,	,,
1873	62,738	,,	,,	,,	,,	,,	,,
1874.	83,690	3/-	2/10	2/8	2/5	2/-	10d.
1875.	5,005	,,	,,	,,	,,	,,	,,

Difficulties from other quarters had presented themselves for solution before the equalisation of the duties, but the necessity for settling them had been partially suspended by the pressure of the burning question of the equalisation of the sugar duties. It has been mentioned in a previous part of this lecture that when the first Napoleon, through being at war with his maritime neighbours, lost the command of the foreign market for the supply of sugar to France, he tried to cultivate the beet for the sugar it contained. Production was stimulated by the fact that sugar in France had risen in price to about 6 francs a pound, and as the consumption of raw sugar in that country was considerable, it was self-evident that the sudden cutting off of supplies caused great inconvenience, and gave rise to dissatisfaction. After much difficulty, the problem of a home sugar supply was solved; it could be produced from beet in sufficient quantity for the national requirements, but the product obtained, though good in colour, was most offensive in smell and taste, and could not be employed as an article of diet without special purification. The French, as well as other nations who had to depend upon beet for their sugar supply, were compelled to manufacture refined sugar for domestic use. Other countries, too, who produced sugar from the cane, made different qualities of commercial sugar, and it was apparent from the descriptions of sugar of varying quality put on the market, that a uniform rate of duty of all qualities of sugar was not just in its incidence, or fair to the consumer. Complaints were made by the representatives of those countries which produced as their staple trade low qualities of sugar, that a uniform duty on all sugar imported was very unjust, while the refiner of sugar, and the producer of best brands of raw sugar were satisfied with a uniform scale. Complaints were so general, and the object aimed at was so just, that an effort was made in 1855 to classify the sugars imported. The classification decided upon was—

	s.	d.	
Refined	16	0	per cwt.
White clayed............	14	0	,,
Yellow Muscovado	12	0	,,
Brown ,, ...	11	0	,,
Molasses................	4	6	,,

The principle thus established was good, and in intention was all that could be desired for an equitable settlement, but as these classifications had to be made with rapidity and despatch, it was apparent that such a novel assessment of value hastily thrust upon Government officials would provoke discontent, and give grounds to persons wishing to upset the classification to say that the assessment had not been correctly made. Dissatisfaction continued to grow till, in 1862, the question was brought before the House of Commons, and a committee was appointed to inquire into the subject and report to the House.

Representatives of all sections were heard, and, as usual, self-interest seemed to guide all the witnesses in their opinions and conclusions.

Our colonial planters considered the classified rates of duty unjustly operated against them in charging their sugars with a higher rate of duty as soon as the quality was improved. The grocers, through their representatives, contended that the classification should be simply into two classes, refined and unrefined, and thus they would be able to obtain a full supply of good grocery raw sugar for consumption.

The refiners were not in favour of one uniform duty, as this policy would shut out of the market the low quality sugars, and thus reduce our importation of those sugars from which they drew their supplies for refining purposes.

With such a conflict of interests it was to be expected that there would be a corresponding divergence of opinion, and as the advocates of the different classes of interests were men of position, and were represented on the Commission, the final report was naturally not unanimous; still the following was carried by a large majority:—

1. That the amount of revenue now derived from sugar could not with justice to the consumers of the lower classes of sugar be raised by any uniform duty applicable to all classes.

2. That it is not possible to charge sugars with duties varying exactly with the quality or value.

3. That it is necessary to maintain the principle of a scale of duties with standards designed to include several classes of sugar within each range of duty.

4. That the duties ought to be so regulated as to encourage the largest possible supplies of sugar from the various sources of production, in whatever form the same may be imported, whether as refined sugar or in combination with other substances, to be afterwards separated by the process of refining.

5. That the existing scale may be rendered more equitable by such an alteration as shall admit at lower rates of duty the inferior portion of the sugars which are now liable to pay 12s. 8d. and 16s. respectively.

6. That sufficient evidence has been laid before the Committee to warrant the conclusion that such alterations might be made without any important risk to the revenue.

7. That the evidence does not justify the Committee in recommending the adoption of refining in bond.

This report, though short, was a very able one, and, in principle at least, was satisfactory; but in its adaptation to trade requirements difficulties of necessity arose, especially with regard to duty assessment and classification. The refiner, since he did not manufacture in bond, had to pay duty on the raw sugar as it went into his factory, and not on the quantity of refined actually made. The question to solve was therefore, taking refined sugar as a standard of quality, what rates should be levied on raw sugars of different grades as regulated by this standard? It was a simple matter for the chemist to find out the composition of any sample of sugar submitted to him, and to express the results in moisture, cane and grape sugar, and mineral matter. But the refiner who had to manipulate the sugar in the process of refining was aware that a chemical analysis, though useful within certain limits, could not be taken as the actual outcome of what was obtained in commercial practice. It has been before stated that glucose prevents its own weight of cane sugar from crystallising, and the soluble alkaline salts act more seriously still in the same direction, especially in the case of beet sugar. Thus it is expected that the refiner, when working on beet sugar, will for every percentage of ash present lose five times as much crystallisable sugar, and in the case of cane sugar three times. These difficulties, arising in construing the chemist's results of analysis into the actual yield of the refiner, were not easily surmounted, and they were further increased by our drawing large supplies of refined sugar from the continent on which drawback had been paid. It was contended by the home refiners that the drawbacks granted by certain foreign countries were too high, and that they acted as bounties, enabling the foreign refiner to put on our market loaf sugar at a lower price than it could be produced here. This complaint soon reached the acute stage, and in November, 1864, a convention was signed between Great Britain, Belgium, France, and the Netherlands, its object being to regulate by common agreement the international questions relating to the laws affecting sugars, and especially to assimilate the drawback on exported refined sugar to the duties on the raw material. A prominent feature of the programme was that a series of experiments should be conducted on a commercial scale to determine the real yield due from sugars of different origins and qualities. Pending these experiments, Article I. regulated provisionally the minimum yields of refined sugar per 100 kilos. of classified raw sugar used, these yields to be modified according to the results of the proposed trials. In 1865 arrangements were made for carrying out the experiments, and it was decided that the sugar to be operated on should be bought in England, the English market offering the greatest variety, and that the refining should be carried on in neutral territory, and the expenses of the experiments shared by the contracting countries.

Cologne was the place selected for the experiments, an approved factory was hired, and the experiments were conducted by practical refiners, under the supervision of the Prussian Revenue officers, and concluded in August, 1866.

In the following month a conference was held between the representatives of the Powers signing the convention and the delegates of the same who had been charged with the supervision of the experiments. The yields of the different operations were worked out, and the provisional estimates in Article I. of the convention were modified accordingly, and were as follows :—

Nos. of Series of Dutch Standards.	Provisional. Minimum yield.	Actual yield by Cologne experiments.
	Kilos.	Kilos.
18, 17, 16, 15.........	87	94
14, 13, 12, 11, 10 ...	85	88
9, 8, 7	81	80
Below 7...............	76	67
Average	82¼	82¼

On the existing rate of duty per cwt. for refined sugar the yields were equivalent to—

	s.	d.	
Refined	12	10	per cwt.
1st Class Raw....	12	1	,,
2nd ,, ...	11	4	,,
3rd ,, ...	10	3	,,
4th ,, ...	8	7	,,

The series of experiments had been difficult of execution, nor were the troubles of the Sugar Convention yet over. In October, 1866, a declaration was signed by the four parties to the convention, accepting the new scale of minimum yields for the duration of the Convention (ten years), and fixing May 1st, 1867, for the commencement of its operation.

In Great Britain an Act was passed in the following April, and the duties and drawbacks were fixed, according to standard, thus :—

	s.	d.	
Refined and Candy..	12	0	per cwt.
1st Class Raw......	11	3	,,
2nd ,, ...	10	6	,,
3rd ,, ...	9	7	,,
4th ,, ...	8	0	,,

An effort was made to bring the convention into effect on March 1st, 1867. Holland declined, and named April 1st instead, but this did not meet with acceptance, and the original date, May 1st, was adhered to.

In principle the convention was agreed to, but France had a method of her own in carrying it out, which gave rise to much bitterness and angry feeling amongst the refiners. By Article IV. of the convention, Powers granting a uniform drawback were to correlate import duties with the yield obtained by experiment. France was not charging a duty at the time the convention was signed, as she had just introduced a system of "temporary free admission" of sugar intended for exportation after refining. She accordingly retained her existing duties, viz., two rates for the four classes of raw sugar.

Below standard 13, 42 francs per 100 kilos.
13 to 20, 44 ,, ,,

As she had no drawback to equalise with duties, the import duty on refined sugar was, by Article XIII., to be 15 per cent. above the duty on raw sugar of the highest class, this percentage to be modified by the results of the experiments. These experiments raised the yield from 87 to 94 kilos, so that pure sugar taken as 100 was only 6·4 per cent.—94 : 100 :: 6 : x ($x = 6{\cdot}4$) — instead of 15 per cent. 87 : 100 :: 13 : x, $x = 15$ per cent.

It was clear enough that in the terms of Article XIII. the yield being altered from 87 to 94, the duty on refined sugar should be modified accordingly, but instead of adhering to the terms of the convention, the French authorities took the average yield of the four classes, which remained the same, and imposed an import duty on refined sugar of 44 fr. + 15 per cent. = 50 fr. 60 c. The British sugar refiners contended that the rate should have been 44 fr. + 6·4 per cent. = 46 fr. 81 c., and that France was, if not paying a bounty, imposing a protective duty on foreign refined sugar. The operation of these rates will be seen in the following Table :—

TABLE X.

Raw Sugar.			Refined Sugar.					
						Effect of higher rate, 50 fr. 60 c.		Effect of lower rate 46 fr. 81 c.
Class of sugar used.	Yield per 100 kilos.	Duty on importation per 100 kilos.	Duty paid by French Refiner per 100 kilos.	Duty paid by Foreign Refiner on importation per 100 kilos.		Surtax on Foreign Refiners per 100 kilos.	Surtax on French Refiner per 100 kilos.	Surtax on French Refiner per 100 kilos.
Nos.		Frs.	Frs.			Frs.	Frs.	Frs.
15—18	94	44	46·81	50 fr. 60 c.	46 fr. 81 c.	3·79	—	—
13—14	88	44	50·00			·60	—	3·19
10—12	88	42	47·72			2·88	—	·91
7—9	80	42	52·50			—	1·90.	5·69
Below 7	67	42	62·68			—	12·08	15·87

The operation of the higher scale was to protect the French refiner on all but the lowest qualities, and the effect of the lower scale would have been to overtax him on all qualities below Standard 15. No understanding could be arrived at between Great Britain and France, though Holland and Belgium read the terms of the convention in accordance with the views of the British Commissioner.

As a compromise, it was suggested that a fresh meeting of the Commissioners who drew up the 1864 convention should take place at the Hague, to determine the matter in dispute. This meeting was held, and resulted in fixing the duty on refined sugar at 48 fr. 85 c. per 100 kilos. In August, 1872, a conference of delegates from Belgium, France, Holland, and Great Britain met to discuss the question of modifying the terms of the convention of 1864, which was considered not to have fulfilled its purpose, viz., the adjustment of tariffs so as to abolish bounties. The remedy advocated by the English representatives was compulsory refining in bond; but owing to difficulties in carrying out such a scheme and the objections raised to it, the conference simply closed with an agreement being entered into by the delegates to invite their respective Governments to inquire into scientific methods of analysis with a view to discover what processes, if any, existed, which were not too technical or lengthy to admit of application on a large scale.

During the year the inquiry was instituted, and the conclusion arrived at was that the colour tests of the standards were faulty, and that a great improvement in the examination would be the application of the polariscope to the determination of the crystallised sugar present. In the following year a conference was held at Paris, and whilst not being able to suggest any remedies, the members were unanimous in opinion that the convention of 1864 had not fulfilled its purpose, and that the principal defects of that convention mainly arose from the fact that the classification of raw sugar by colour was liable to large errors; that sugars of different origin and of widely-different saccharine value got into the same class; that the different shades of sugar from which one particular per-centage yield was required extended over too wide a range; a trader by systematically using the best in one class could get a small bounty on the whole refined produce; that raw sugars were, for the purpose of evading the duty, artificially darkened to appear worse than they were; and, further, that British refiners obtained drawback on half-refined sugar (pieces) as refined sugar, by decolouration through charcoal.

Refining in bond, which was again suggested as the only true remedy, was objected to on the ground of expense, and, as a half-way measure, it was suggested that optical saccharimetry should be made a part of the official determination of the value of sugar, and that the classes of sugar should be either increased in number or suppressed altogether. From so many repeated failures it was evident that the question of bounties was one which was looked upon differently in the countries interested, and, as there could be found no common ground of agreement, it was apparent that conferences and discussions could do little to solve the problem. In 1876 another conference was held in Paris, to consider a modified scheme of refining in bond presented by the Dutch delegates. This scheme consisted of taking account of all sugar entering the refinery, duty being levied upon the refined sugar as it passed into consumption, no import or export duty, and each country to be free to abolish or fix its own rate of duty on sugar for home consumption. A Belgian scheme, based on a French method of saccharimetry, and revision of types or standards, was also considered, and the French representatives expressed themselves favourable to levying surtaxes on sugars from countries paying bounties.

None of the proposals obtained general assent, and after delays and discussions innumerable, nothing was done to get over the bounty system.

The sugar industry of this country having been almost ruined by the system of foreign bounties, the subject was brought before the House of Commons, and a select committee was appointed, which recommended a conference of the sugar-producing Powers of the world, and accordingly invitations were issued in 1881.

Side issues were raised by different Governments, which had the effect of delaying the assembling of a conference, and in some cases conditions were imposed which could not be accepted by other Powers. Associations interested in the sugar trade, and in the abolition of bounties, kept up an agitation till 1887, and in this year the Government was nduced to open up negotiations for a conference.

It will be at once apparent, from the length of time the agitation continued, that it was not a distinctly political question, and from the number of countries interested, we can see that the question to be settled was one of vast importance, and considered so by politicians of all shades of opinion. Preliminaries for a conference were settled, and at last, in July, 1887, a formal invitation was issued from the Foreign-office to the countries concerned. On November 24, representatives from the following countries met in London, under the presidency of Baron de Worms:—Germany, Austria-Hungary, Brazil, Denmark, Spain, France, Great Britain, Italy, Netherlands, Russia, and Sweden. Portugal, Norway, and Roumania declined, because they were not interested in the question. The United States was not officially represented, but the Secretary to the United States legation attended some of the meetings.

Seven sittings were taken up with considering the question involved, and drawing up a draft convention for the consideration of the respective Governments represented. This draft engaged the Powers to afford complete guarantees against bounties, to levy duty (if any) on the amount of sugar actually destined for home consumption, by a system of manufacturing and refining in bond.

Belgium made a reservation in favour of retaining the prevailing system of charging duty on the sugar syrup, her reason for so doing being that refining in bond was deemed to be impracticable. As a compromise she offered to raise the estimate of produce on which the charge was based, and lower the duty to a point which she considered would practically abolish bounties.

During April and May, 1888, the conference sat in London, and amplified the draft convention on the following bases:—

1. Government supervision of factories and refineries.

2. The exclusion or taxing of bounty-fed sugar.

On August 30th of the same year the convention was signed by the representatives of Great Britain, Germany, Austria, Hungary, Belgium, Spain, Italy, Holland, and Russia. Austria's adherence was conditional on the agreement of all other sugar-producing European powers to join the convention at or before the time fixed for its coming into force, viz., September 1st, 1891.

Denmark and France declined to sign, the former objecting to the exclusion of bounty-fed sugar as liable to clash with the most favoured-nation clause in her treaties, and the latter deferring her adhesion till all sugar-producing countries had joined the Union. France, however, if she has not adopted the true economic principle as regards bounties, has at length begun to feel the burden of her present system too heavy, and is now seeking to reduce it considerably. A recommendation now made by the Government will, if adopted by the Chamber, lower the amount with which the French refiner is practically subsidised by 30 to 50 per cent., and, leaving him less able accordingly to cope with his foreign competitors, must diminish to a large extent the supply of refined sugar to this country. As it is not impossible that Germany and other continental sugar-producing countries may pursue a similar policy, the stimulus to abnormal production will be largely withdrawn. Such a partial disappearance of foreign competition would, of course, greatly benefit the English refining trade, though probably the English consumer would miss the bonus virtually given to him by the foreign taxpayer when, as would no doubt be the case, the present low prices of sugar had risen to something like their former level.

The convention is still, however, beset with difficulties, and it may even now happen that, from causes which cannot be here touched upon, the whole work may have to be done over again before a satisfactory settlement is made.

BOUNTY-FED SUGAR: ITS MEANING.

From what has been said when dealing with the classification of sugars for duty, it is evident that different descriptions of sugar, as well as many of the same kind, vary greatly in composition. As long as raw sugar was consumed as such, the variations in its composition were not so apparent as when much of it was refined and exported to other countries.

To enable the home manufacturer to compete fairly in foreign markets, it is the rule that the duties which have been paid on the goods exported shall be returned at the time of shipment, and this return of duty is called the drawback.

When such goods are exported in the same condition as they were in when the duty was charged, there is no difficulty in granting an equitable drawback.

If, however, the goods be charged with duty in one condition and exported in another, there is considerable difficulty in assessing the drawback, and this is the case with refined sugar. The duties on the raw sugar are, in the case of beet, levied on an assumed yield of sugar from a certain quantity of roots or juice, and in the case of raw sugar, on the quantity of refined sugar a certain weight is supposed to yield. In practice, the *real* is greater than the *estimated* yield, and as a consequence there is a certain quantity of refined sugar produced, on which no duty has been paid. If this excess quantity be consumed in the country of production, the sugar refiner benefits at the expense of the home consumer, the price charged for the duty-free sugar being the same as that on which duty had been paid. If, however, any portion of this duty-free sugar be exported, the exporter receives from the State the duty which should have been paid on the sugar by the refiner, which is, to all intents and purposes, a present to him from the taxpayers of the country through the Government. This bounty is generally applied by the exporter in underselling his foreign com-

TABLE XI.—CALCULATED BOUNTY ON SUGAR.

	France. (1887.)	Germany. (1888 Law.)	Belgium. (1887.)	Holland.
1. Total production of sugar........................(tons)	555,000	90,000	150,000	36,000
2. Estimated proportion of surplus sugar manufactured to total (1)	36½ per cent.	25 per cent.	20 per cent.	16 per cent.
3. Amount of surplus sugar ....(tons)	200,000	250,000	30,000	6,000
4. Rate of duty........................	50 frs. per 100 kilos, + 10 frs. on all sugars.	10/3 per cwt.; viz., 6/- on all finished sugar, and 4/3 on the roots.	45 frs. per 100 kilos.	27 fl. per 100 kilos.
5. Estimated total loss of revenue from surplus sugar escaping duty.	£4,000,000	£1,000,000	£550,000	£162,000
6. Estimated bonus on production, dividing total loss of revenue by quantity produced.	£7 4s. 0d. per ton.	£1 per ton.	£3 13s. 0d. per ton.	£4 10s. 0d. per ton.
7. Total sugar exported ....(tons)	159,000	619,000	111,000	96,000
8. Apparent bonus on export, dividing total drawback on surplus sugar exported by total quantity exported.	£3,180,000, or £20 per ton.	£1,000,000, or £1 12s. 0d. per ton.	£550,000, or £5 per ton.	£162,000, or £1 14s. 0d per ton.
9. Estimated bonus on production, dividing total drawback on surplus exported by quantity produced.	£5 14s. 0d. per ton.	£1 per ton.	£3 13s. 0d. per ton.	£4 10s. 0d. per ton.

petitor, and the rivalry thus created forces down the price of sugar, and enables the consumer of the foreign sugar to participate in the gift made to the exporter by the taxpayers in the country of its origin.

To show how this system of drawback works, a study of the following Table prepared by the Board of Trade will appeal to the understanding much more forcibly than any words of mine can do; because the quantities of surplus sugar made are given, and the amount of money which is taken out of the pocket of the taxpayer as a present to the sugar refiner.

TABLE XII.—CALCULATION OF BOUNTIES.

	Total bounty on Export.	Rate per ton on Surplus Exported.			Rate per ton on production.		
	£	£	s.	d.	£	s.	d.
France	3,180,000	20	0	0	5	14	0
Germany	1,000,000	1	12	0	1	0	0
Belgium	550,000	5	0	0	3	13	0
Holland	162,000	1	14	0	4	10	0
Austria-Hungary	500,000	Bounty does not arise on export surplus.					

The figures given show how heavily the countries named are taxed to favour the sugar refiners, or rather to encourage the home manufacturer of sugar. In a young and rising country such protection may be excused, because it fosters home trade and enables different manufactures to be profitably established at home. But on the other hand, it cannot be denied that such favours granted to those engaged in any special manufacture must be made at the expense of the general taxpayer, who derives comparatively no benefit from the concession; that bounties when given have a tendency to increase the cost of production and to limit improvements in manufacture, to foster the maintenance of large profits at the expense of the general community, and to destroy legitimate competition which has proved so beneficial to improvement in manufacture, and the lowering of prices to the consumer.

The experience of the past and present confirms these views, and we may close this lecture with an apt quotation from McCulloch on the subject under consideration:—"The history of all businesses carried on in this country by the aid of bounties proves that they are hardly less disadvantageous to those engaged in them than to the public."

General Notes.

FIELD CLASSES.—The scholastic journal, *Education*, announces in its last issue that it is prepared to undertake the organisation of field classes for metropolitan schools, if a sufficient number of headmasters of such schools are willing to join in the movement. The classes are to be geological during the winter, and botanical and entomological in summer, they are to be conducted by qualified specialists, and at a cost only sufficient to cover working expenses.

ERRATA IN PROF. SILVANUS THOMPSON'S CANTOR LECTURES ON "ELECTROMAGNETS."

Page 863, col. 1, line 27 from top, for *precisely as* read *precisely like.*
,, 868, col. 2, line 14 from bottom, for *number* read *length.*
,, 870, col. 1, line 9 from bottom, for *convexion* read *connexion.*
,, 871, col. 1, line 25 from top, for 1867 read 1857.
,, 874, col. 1, line 10 from bottom, for *decidedly* read *directly.*
,, 889, col. 2, line 9 from top, for *upper* read *copper*; col. 2, line 33 from top, for *total* read *quotient.*
,, 891, col. 2, lines 15 and 17 from top, for 3133 read 3132.
,, 892, col. 2, line 1 from bottom, for *reversing* read *severing.*
,, 896, col. 1, line 15 from bottom, for *big* read *heavy*; col. 2, line 12 from top, for *permeability* read *induction*; col. 2, lines 25, &c., from top, for 3133 read 3132.
,, 898, col. 2, line 5 from top, for 903000 read 90300.
,, 917, col. 2, line 14 from bottom, for *be the* read *be to the.*
,, 926, col. 1, line 27 from top, for $1\frac{1}{2}$ read $\frac{2}{3}$; col. 1, line 33 from top, in last formula, for $\times$ read $+$.
,, 929, col. 2, line 17 from top, for *resistance* read *resisting space.*
,, 931, footnote, lines 9 and 6 from bottom, for 4·2 read 0·24; footnote, line 3 from bottom, for $17\frac{1}{2}$ read 3·4; footnote, line2 from bottom, for *minute* read *hour.*
,, 936, col. 2, line 13 from bottom, for *length* read *volume.*
,, 943, col. 1, line 3 from top, for 2 read 10; col. 1, line 12 from top, for *within* 5 read *within* 95; col. 2, line 19 from top, for 200 read 400.
,, 945, col. 1, line 9 from top, for 0·5 read 0·96; col. 1, line 10 from top, for 0·96 read 0·5.

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NOTICES.

EXAMINATION PRIZES.

The Mercers' Company have made a grant of £21 to the Prize Fund of the Society of Arts' Examinations. The manner in which this amount will be distributed in prizes will be announced hereafter.

The Clothworkers' Company offer First, Second, and Third Prizes of £5, £3, and £2 to candidates obtaining a First-class Certificate in Italian and Spanish respectively, and certified as proficient by the Examiner.

These Prizes are supplementary to the Medals offered in each subject by the Society.

Proceedings of the Society.

CANTOR LECTURES.

SUGAR, COFFEE, TEA, AND COCOA, THEIR ORIGIN, PREPARATION, AND USES.

By Richard Bannister.

Lecture II.—Delivered May 5th, 1890.

Sugar was chiefly referred to in our first lecture as a commercial article, presented to the public under many forms and qualities, but it would be doing an injustice to two very important and growing industries if nothing was said respecting the use of sugar in jam making and allied industries, as confectionery and sweets, and, in the second place, in the brewing of beer. The cheapness of sugar has caused it to be largely employed in jam-making and brewing, and in the brewing of beer. Tables of consumption have been prepared for reference, which will illustrate the advance made in the use of sugar as an adjunct to, and frequently as a substitute for, malt in brewing the malt liquor of commerce, and for which Great Britain and Ireland have long been famous.

Jam-making and Confectionery.

The quantity of sugar used in jam-making and confectionery is very large, but there are no statistics available to show what is thus consumed. It has been computed that the quantity used in Scotland is about 40,000 tons per annum, and this is steadily increasing, on account of the large quantity of land which is being put under fruit cultivation, and especially to the growth of strawberries. The soil of certain districts is admirably suited for strawberries, and as far north as Aberdeen they are cultivated very extensively.

In England fruit culture is steadily advancing, and the quantity of sugar required for preserving is necessarily on the increase. An estimate has been made, and published in an official document, that seven of our leading London jam-makers and confectioners use 34,000 tons of sugar per annum. It would be interesting to know what is used in the entire trade, and at a future time the consumption may be considered of sufficient importance to justify the preparation of such a return.

Sugar is not used in the manufacture of jam simply to impart sweetness, but it acts as a very reliable preservative of the fruit. Its antiseptic and preservative properties are considerable, and this is recognised in the curing of hams and other meat as well as in the preservation of fruit. When sugar was very dear, and fruit comparatively cheap, it was a common practice to put fruit in bottles, then to partly cook the fruit by putting the bottles in hot water, and afterwards to exclude the air by suitable means. The operation was generally imperfect, and only kept the fruit a very short time. As soon as sugar became cheap it was used as a preservative, and, in smaller or larger quantities, its use with fruit is now general.

Each manufacturer of preserves professes to have a specialty of manufacture, by which the preservation is more perfect, or the fruit retains special characteristics of appearance or flavour.

The modern jam manufacturer endeavours to produce jam which possesses in a marked degree the natural colour and also retains the natural form of the fruit. All fruits are not alike in this respect, but whenever this object can be attained, the practised jam maker shows his finished jam to the public as whole fruit in a thick syrup. Some manufacturers use glass vessels instead of earthenware, to make the colour and character of their jam appeal more strongly to the senses, and from the success which has attended this movement it is evident that the general public appreciate their effort to exhibit, in such a popular and self-evident manner, the improved make of preserves. The low price of sugar has been the chief motive power in this marked advance in jam-making. Sugar can be used in larger quantity, and thus the jam is now preserved with less boiling. Long boiling always deteriorates the quality of jam ; its colour is darkened, the fruit is broken up, the flavour injured, so that jam thus made, even from the best materials, is in look and taste no better than that made from faulty fruit. There is no doubt that the modern method of jam-making has been to some extent brought about by the desire to imitate some of the elegant French products imported, and the French deserve great praise for their ability to appeal to the eye as well as to the taste in preparing such familiar family requirements as preserves, confections, &c. It is, however, necessary that, even in modern jam-making, the fruit when mixed with the sugar should be speedily raised to the boiling point, and kept steadily boiling till the operation is completed. In fruits there are, as in the sugar-cane and the beet, active nitrogenous substances which will quickly change cane sugar into other descriptions of sugar crystallising quickly, and this action is most rapid considerably below a boiling temperature. If this chemical change be allowed to take place, the jam when kept will crystallise, and to the uninitiated the jam looks as if it was deteriorating by fermentation.

Manufacturers, knowing the bad effects of long boiling, are apt to fall into the opposite extreme, and neglect to boil either long enough or quickly enough. They overlook the fact that such treatment is favourable to the chemical change before-mentioned taking place, the conditions according closely with those which prevail when the fruit is allowed to remain long on the tree. A batch of jam will become granulated and unsightly, whilst another boiling, made with a portion of the same fruit and sugar, in similar proportions, will remain bright, clear, and satisfactory in every respect. The difference is simply due to the fact that, in the first batch, the invertase of the fruit at the temperature of the operation acted on a portion of the cane sugar and inverted it, and this sugar on keeping became granular, and gave the jam its unsightly appearance. When the cause is known, it is easy to guard against future mishaps ; but the discovery of the fault presents difficulties, even to the chemist, and without the aid of chemistry the investigation would be almost certain to be barren of results. We have seen a jam maker of large experience troubled from this cause. The jam was sound but granulated, and by the uninitiated was said to be in a condition of incipient fermentation. The cause was traced, and future mistakes avoided ; but the faulty jam in the hands of the retail trade did the manufacturer much injury, as it directed particular attention to the jam of his manufacture, and prejudiced the public against it.

There is a description of sugar known in the trade as liquid glucose, imported largely from France, and commonly used by jam makers when preserving faulty fruit. In making fruit jellies and syrups the fruit has to be deprived of a large portion of its juice. The residue is commonly made into "family jam," and to restore to some extent the natural condition of jam made from whole fruit, glucose is extensively used, and, as it will not crystallise, it readily lends itself for this purpose. Such jam has a fair colour, but the abundance of fruit seeds in it, and the deficiency of fruit flavour, indicate at once its origin.

Cheap sugar fosters the manufacture of cheap jam, confectionery, and sweets, and perhaps in no branch of industry have greater strides been made than in fruit-growing and preserving on account of the cheapness of sugar.

SUGAR USED IN BREWING AND DISTILLING.

Before 1847 no sugar was allowed to be used by distillers except that which was duty-paid, and it was not permitted to be used as a substitute for malt in brewing beer. Malt, although liable to an Excise duty, was allowed to be used duty free in distilleries, the duty being charged on the spirit produced from it.

The West India sugar planter, who was at that time the principal sugar producer, complained of the injustice done to colonial sugar in prohibiting it from being used, like malt, duty-free in distilleries, and in 1846 public attention was directed to the subject. At that time it was not known what the value of sugar as compared with malt was to the brewer and distiller, and experiments were made by Messrs. Phillips and Dobson, of the Inland Revenue department, to settle these points to the satisfaction of the trade and the revenue. When this had been done, there was no difficulty in discussing the sugar question in the spirit of justice and fair dealing. The ground taken by the sugar producer was so sound and just that, in the year 1847, sugar was permitted to be used in distilleries duty free, and in breweries on the payment of a Customs and Excise duty equivalent to that charged on the malt for which it was used as a substitute.

From that time to the present sugar has grown in favour with brewers, and the reasons for its doing so arise generally from two causes, viz., the altered taste of the public, and the facility with which sugar lends itself to the brewer's purposes for producing the beer now suited to the taste of the ordinary beer drinker.

The beer in fashion before the introduction of sugar was made from malt and hops only. It was generally brewed in winter and kept for summer use, and to ensure its continuing fairly sound it was heavily hopped. Such beer took a long time to get bright and fit for use unless aided by the addition of "finings," which speedily clarified the beer and made it brilliant; but though some of the beer was then artificially clarified, the greater part was stored in vats, and kept for very long periods. At that time wine was not a common drink, as it is now, and therefore in the houses of the rich home-brewed ale was a fashionable drink; and it was considered a valuable acquisition to possess old ale which had been brewed for periods up to twenty years and more, in fact, brewed when the heir was born, and drunk when he came of age. Brewers stored their beer in vats and kept it till it had acquired the somewhat sour flavour of old ale, but some descriptions of badly-brewed beer speedily got sour, and this was sold as old ale. In the West of England, and in Belgium, this fashion of drinking old ale has not yet died out; but in other parts of this country, and throughout the beer-producing States of the world, the public taste has run in favour of mild ale and

TABLE XIII.—QUANTITIES OF SUGAR AND MOLASSES USED IN BREWING AND DISTILLATION IN THE UNITED KINGDOM IN EACH YEAR FROM 1847—1890.

Year.	In the Brewing of Beer.	In the Distillation of Spirits.		Barrels of Beer brewed in the United Kingdom.
	Sugar.	Sugar.	Molasses.	
	cwts.	cwts.	cwts.	
1847....	72,453	20,460	—	—
1848....	24,887	10,849	2,075	—
1849....	16,421	3,389	16,969	—
1850....	9,869	5,273	22,369	—
1851....	6,589	—	15,193	—
1852....	7,277	10,759	100,209	—
1853....	13,251	524	44,799	—
Year ended March 31.				
1855....	22,807	11,905	187,006	—
1856....	15,440	25,710	155,556	—
				March 31.
1857....	20,793	346	94,133	17,984,773
1858....	27,796	692	3,212	18,166,635
1859....	25,553	997	15,413	19,152,564
1860....	54,664	101	49,527	20,340,096
1861....	85,304	18	32,178	19,534,460
1862....	77,840	11,292	391,443	19,989,313
1863....	91,543	12,832	244,431	20,081,408
1864....	70,535	1,641	85,064	21,360,461
1865....	33,019	1,251	26,659	22,546,889
1866....	68,765	3,114	28,004	25,388,600
1867....	243,868	5,028	86,582	25,206,665
1868....	356,089	13,884	61,520	24,301,841
1869....	369,350	321	137,417	24,542,664
1870....	295,865	1,278	61,143	} cannot be given.
				Sept 30.
1871....	285,266	909	194,275	26,431,760
1872....	260,610	1,477	202,386	28,270,511
1873....	417,091	4	247,593	29,774,988
1874....	613,988	10	233,578	30,670,081
1875....	868,943	8,665	89,327	31,014,381
1876....	879,328	1,808	86,526	32,279,459
1877....	834,052	—	178,779	31,988,991
1878....	956,287	—	220,549	32,083,824
1879....	1,101,936	—	191,654	29,767,075
1880....	1,136,434	—	322,899	30,742,649
1881....	1,280,134	—	212,084	27,352,361
1882....	1,142,845	103	179,759	27,847,308
1883....	1,130,811	237	170,665	27,114,202
1884....	1,128,232	—	212,474	28,058,248
1885....	1,217,019	3,109	367,460	28,663,760
Year ended Sept. 30.		31st	March.	
1886....	1,309,964	—	341,087	28,234,175
1887....	1,465,939	12,355	168,074	29,286,849
1888....	1,523,870	20,047	221,442	29,199,088
1889....	1,810,714	38,317	210,621	31,023,818
1890....	—	31,152	211,464	—

porter. Consequently, the vatting of malt liquor is now seldom attempted, and ale is brought to maturity in the casks into which it is racked at the time the beer is brewed.

Quickness of consumption has thus been fostered, and to meet this new state of things the brewer has been led to use fewer hops than formerly, and to employ in conjunction with the malt from 5 per cent. to 25 per cent. of sugar. This addition of sugar reduces the quantity of albuminoids and dextrin present in the liquid extract or wort produced in the operation of brewing, and causes the beer obtained from this mixture of malt and sugar to get bright more readily than if malt only had been used, and to have a palate-sweetness appreciated by the ordinary beer consumer.

There is no doubt that this change in the public taste has had the effect of reducing the price of beer, because the brewer can better utilise his plant than formerly, and work with comparatively less capital. The beer brewed goes quickly into consumption, and the brewer's aim is to produce an article which is adapted to the wants of his customers in the shortest time he can.

During the transition period referred to, the chemistry of brewing has received much attention, and the composition of the materials used, and the chemical changes which take place in the different brewing operations have been carefully and intelligently worked out in France, Germany, Denmark, and Great Britain. The result is that brewing has been reduced to a fairly perfect science, and any typical beer that may be required can be produced at will.

This knowledge has been brought into profitable use in the selection of brewing materials, and special articles have been manufactured from sugar and grain to suit the brewer's requirements. Invert sugar, glucose, torrefied grain, special preparations of rice and maize, are some of the many malt substitutes, or malt adjuncts, employed by brewers, and it is only just to mention that each kind has its special characteristics to commend it to the favour of the brewer who has the requisite knowledge to benefit by its use, and to utilise it in the production of the article for which it is specially suited. In this connection it may be of interest to show how malt, and the most general malt substitutes, are assessed with different rates of duty, according to the purpose for which they are used.

		£	s.	d.
	One quarter (8 bushels) of malt used to produce as malt duty	1	1	8½
	,, ,, ,, produces as beer duty..............................	1	5	0
	,, ,, ,, will produce 18 gallons of spirits at proof, duty 10s. 6d. a gallon..	9	9	0
	One quarter of malt and grain, 20 gallons spirits, duty	10	10	0
Free.	One cwt. of sugar will yield 10 ,, ,, ...	5	5	0
	,, molasses ,, 7 ,, ,, ...	3	13	6
	,, rice ,, 7½ ,, ,, ...	3	18	9
	One ton of beet-root ,, 15 ,, ,, ...	7	17	6

The distiller has argued that he is more heavily taxed than the brewer, and his standard of taxation is naturally the duty on spirits, and the quantity upon which he has to pay. The brewer, on the other hand, draws a distinction between spirits and beer, and the point he raises in his defence is that beer is a food as well as a drink, and, having become a necessary of life, should not be treated as an intoxicant like spirits, and the Legislature has hitherto very properly made a similar distinction.

COFFEE.

History.—The coffee plant is a native of Arabia and Abyssinia, but it is now naturalised generally in tropical countries, and is specially cultivated as an article of commerce in the West Indies, South America, and other parts of the world where the mean temperature of the year is about 70° F.

Its early history seems not to have been known to the Greeks and Romans, but in North-East Africa it has been used from time immemorial, and as far as its history can be traced, it does not appear that orthodox Mahometans have always looked upon it with favour, or thought that it was a harmless beverage. About the beginning of the 15th century it seems to have come prominently into notice, and its cultivation spread from Aden to Mecca, Cairo, Damascus, and Aleppo, and reached Constantinople from Syria, in 1554, in the reign of Solyman the Great.

Khair Beg, the governor of Mecca, was unacquainted with the preparation of coffee or its qualities, and leaving the mosque one day, he saw some devout Mahometans whose duty it was to spend the night in prayer, drinking something which seemed to have an effect on their nerves similar to that of an intoxicant. At this sight he was much surprised and also offended, and when told the character of the drink, he was still far from satisfied that it could be drunk by the faithful.

The subject was of sufficient importance to court inquiry, and on the following day the learned of the city were called together in convocation, and the subject of coffee drinking was thoroughly discussed, Two celebrated Persian physicians maintained that coffee could not be legally drunk by Mahometans, on account of its stimulating properties. This view was approved, and in the face of some opposition an edict was issued forbidding its use. Shortly afterwards a coffee drinker caught in the act was publicly bastinadoed.

The action of the Governor was reported to the Sultan of Egypt. He revoked the order, recalled the Governor, and, according to the records of the time, he caused the two physicians to come to an untimely end. The question of the use of coffee had become essentially a religious one, and, notwithstanding the prompt action of the Sultan, it was once more prohibited, but afterwards again permitted.

In Cairo, in the year 1523, a fashionable doctor set up a crusade against the use of coffee, on the ground that it was prejudicial to health, and that on account of its intoxicating qualities it was not a lawful drink for the faithful. Coffee-houses were, however, common, but ten years later a preacher vigorously denounced the coffee-houses, with the result that a mob broke into them, destroyed the pots and dishes, and abused the company found in them.

The Judge-in-Chief held that the question had long ago been decided in favour of coffee, and ordered coffee to be served to the people assembled, he himself taking the first cup. After this episode coffee became more popular than ever.

In Constantinople coffee soon came into common use, and coffee-shops were established throughout the city. Here, again, opposition was encountered, and the coffee-house became a battle ground for religious bigotry, the priests being annoyed that while the mosques were empty the coffee-houses were full. A petition was got up by priests, zealots, lawyers, and doctors, and was so numerously signed by those who depended for light and leading on the priests, that the Mufti closed the coffee-houses, and prohibited the drinking of coffee altogether.

The public coffee-houses might be compulsorily closed, but it was quite impossible to carry out the regulation in private life. Some persons continued to drink coffee because they liked it, others followed the practice because it was prohibited, and between the two the number of coffee drinkers became large enough to defy the prohibition, and at last the police, unable to carry it out, took bribes from those who violated the law. Such a state of things could not continue, and with a new Mufti the prohibition was removed. It was then seen from the number of the people who drank coffee that the prohibition had proved an effective advertisement for the coffee-house keepers, and from that time to this coffee has been looked upon by the Turks as a pleasant and comforting beverage, stimulating without intoxicating, and suitable as a drink for the most orthodox Mahometan.

The first European who mentions coffee is said to have been a physician named Prosper Alpinus, who went to Egypt in 1580 in the capacity of physician to a Venetian consul. This physician used his position to make himself acquainted with the botany of Egypt, and in 1592 he published in Venice his "History of the Plants of Egypt." In this history he gives an account of a tree whose seeds were much used by the Arabs and Egyptians for making a drink. The seeds of the tree he called "bon" or "ban," and by decoction they were converted into a drink much used by Egyptians and Arabs, and to which he ascribes special qualities and virtues. In another work, "Medicina Egyptiorum," published in 1591, Prosper Alpinus gives an account of the tree nearly identical with that before mentioned, and fully describes the method of preparing the beverage—which he calls "chaoua"—from both the seeds or berries and their husks. This account has been generally overlooked by writers on coffee.

A German physician named Leonhart Rauwolff, who was a great Eastern traveller, also notices coffee. He says that when at Aleppo, in 1573, this drink was there used, and he thus describes it:—

> "They have a very pleasant drink called *chaube*, which is almost as black as ink. It is good for illness, chiefly that of the stomach: and is made of a fruit called Bunnu, which in bigness, shape, and colour resembles a bay-berry. It is surrounded with

two thin shells, and, as I was informed, is brought from the Indies. These shells have within them two yellowish grains in two distinct cells, and agree in their virtue, figure, appearance, and name with the the Bunchum of Avicenna, and the Banca of Rhasis, therefore I shall consider them the same until I am better informed by the learned."

Faustus Bainesius, who wrote the first known treatise expressly dealing with coffee, inclines to the same opinion as Rauwolff. This work was printed in Rome in 1671, and bore the title, "De saluberrima potione Cahu, seu Cafe nuncupata." In 1674, one Velschius contended that coffee was not "bunchum." The two works of Prosper Alpinus on the medicinal and other plants of Egypt, which have been previously referred to as having been published in Venice, appear to have had little or no effect in making coffee a familiar drink to the Italians, for in 1615 coffee as a beverage seems scarcely to have been known in Italy. It seems, however, to have become known, as a curiosity at least, in most European countries, and in those having commercial relations with the East it became sooner known as a beverage. Du Four, who wrote on coffee in 1685, says the French knew nothing of it until 1645, and that it was not used in France till 1657. Galland says that Thevenot, who returned from the East in 1657, then introduced it into France. When in the East he drank it constantly, and on his return home he introduced it to his friends at his house in Paris.

La Roque wrote a book of travels in 1715, entitled, "A Journey into Arabia Felix," and in it he admits that Thevenot was the first who taught the French people the use of coffee; but he at the same time contends that his father, who had been to Constantinople with the French Ambassador, brought back with him the Turkish implements for preparing coffee, and as early as 1644, when he returned to Marseilles, drank coffee every day.

In 1671, a coffee-house was opened at Marseilles. It was considered as a great curiosity, and attracted much attention. La Roque states that coffee was not known in Paris before 1669, although it had been used previously by Thevenot, in his own house, as a beverage. Its introduction into Paris was brought about by the visit to Paris of Solyman Aga as ambassador from Mahomet IV., and it was through this embassy that the idea of opening a public coffee-house was first entertained. In 1672, an Armenian named Pascal sold coffee publicly at the fair of St. Germain, and afterwards, in the same year, opened a coffee-house on the Quai de l'Ecole, which was the first public coffee-house ever known in Paris.

Owing to our maritime advantages, coffee was known in England some years earlier, and the "Journal des Scavans," published in 1675 (28 Jan.), affirms that the English knew the use of coffee twenty years before the French did.

Biddulph, an Englishman, writing from Aleppo in 1603, says:—"The Turks have for their most common drink coffa, which is a black kind of drink, made of pulse like peas, called coava, which being ground in a mill, and boiled in water, they drink it as hot as they can suffer it, which they find to agree with them against their crudities and feeding on herbs and raw meat. It is more wholesome than toothsome for it causeth a good concoction, and driveth away drowsiness."

William Finch, an English merchant in the East India Company's service, wrote, in 1607, that:—"The people of the island of Socot(o)ra have for their best entertainment a china dish of coho, a black bitterish drink made of a berry like a bay berry, brought from Mecca, supped off hot, and it is reckoned good for the head and stomach." None of the writers, either English or foreign, say a word about the coffee being roasted, but roasting seems to have been general from the fact that many describe the liquor of the infusion as dark, Rauwolff being very emphatic in comparing its colour to ink. The first coffee-house in London was opened in 1652, and the circumstances which led to it are worth recording as showing how large industries often arise from certain incidents which may be considered only accidents.

Mr. Daniel Edwards, a Turkey merchant, returned from Smyrna in 1652, and brought with him to London a Ragusian Greek, named Pasqua Rossée. This man prepared coffee for his master's breakfast in London as he had done in Smyrna, and the novelty of the beverage, as well as the desire to partake of it, so excited the curiosity of friends and acquaintances that visitors poured in to Mr. Edwards, and so took up his time that the fore part of the day was lost in satisfying their wants and explaining the nature and origin of the beverage supplied.

Necessity, the mother of invention, prompted Mr. Edwards to devise a plan which would satisfy his friends and the curious, and at the same time would allow him to have the command of his own time without interruption. The plan was to open public rooms in which his Greek servant would make and sell coffee to the public. This shop or coffee-house was situated in St. Michael's-alley, Cornhill, and was without doubt the first coffee-house opened in London. The fashion of coffee drinking soon spread, and the attention of the authorities was soon directed to these public places of resort, and to impose some check upon them, it was enacted by 12 Car. II., cap. 24, that a duty of 4d. a gallon should be imposed on all coffee made or sold.

It was evident that the coffee-houses of those days were distasteful to the authorities, for in 1663 (15 Car. II., c. 9, s. 15) it was made illegal to keep coffee-houses unless licensed by the General Quarter Sessions for the county in which they were kept.

These coffee-houses became places for social meetings, and eventually for political ones. Owing to the turbulence of the times such meetings were not permitted, but before they could be put down, it was found necessary to close the coffee-houses altogether in 1675, and power to close them was given by the following proclamation, dated 29th December, 1675:—

> "Because of such houses, and by occasion of the meeting of disaffected persons in them, divers false, malicious, and scandalous reports were devised and spread abroad, to the defamation of his Majesty's Government, and to the disturbance of the quiet and peace of the realm."

Such a gross interference with the liberty of the subject was not submitted to without protest, and eventually the whole matter was referred to the Judges for decision. In their great wisdom it was laid down, "That retailing of coffee might be an innocent trade, but as it was used to nourish sedition, spread lies, and scandalise *great men*, it might also be a common nuisance." This prohibition was too drastic to last, and afterwards coffee-houses were allowed to be opened, the Excise duty being charged not on the liquid as before, but on the berry at the rate of 2s. a pound.

The English and Western European markets were entirely dependent on their supplies from the Egyptians and Arabs, the berries when in their commercial state being incapable of growth. Every effort was made to obtain a coffee plant, or seeds that would germinate. It has been said that at Dijon, in 1670, a Frenchman obtained plants and grew them to maturity. The seed was, however, tasteless and insipid, and appeared to have served no purpose beyond the gratification of curiosity.

Boerhave states that a Dutch Governor got berries from Mocha and planted them in Batavia. In 1690 a plant was said to have been sent to Amsterdam, which came to maturity and furnished the berries which became the parent stock of the coffee plants of the West Indies.

In 1714, a plant from the botanical garden at Amsterdam was sent to Louis XIV., and it was placed in the garden at Marly. A little later the Dutch began to cultivate coffee in Surinam; in 1721, the French commenced the same cultivation in Cayenne, and in 1728 the English in Jamaica.

The introduction of the coffee plant from Arabia into different countries where it is now grown seems to have been done by the Dutch when their foreign commerce stood higher amongst European nations than it does now. It is said that seeds from Mocha were planted in Java, and from there a plant was taken to the Botanical Gardens at Amsterdam. Cuttings from it were taken to the Dutch colony of Surinam, and from there to Berbice and Demerara, which were then under the rule of Holland. The commencement of coffee-growing in the West Indies led the French to try and start it too in their colonies, whose climate was favourable to the cultivation of coffee. It is said that owing to the jealousy of the Dutch, a Frenchman could only get a cutting from the Botanical Gardens at Amsterdam by actual theft.. It is recorded that he thus obtained a shoot, which was taken to Paris and cultivated. In 1720, a French officer, named Declieux, sailed for the West Indies with one small plant obtained from the shoot in question. It was a long and tedious voyage, the water was consequently diminished in supply, but Declieux looked to the wants of the plant first and himself afterward, watered it from his daily allowance, kept it in good health, and at last landed in Martinique, where the plant grew and eventually became the stock from which sprang the plantations of Guadeloupe, Jamaica, Porto Rico, Hayti, Cuba, the Lesser Antilles, Central America, and all South America, excepting, of course, the Dutch possessions.

Description of Plant.—The genus "Coffea" (family *Rubiaceæ*) comprises about 60 species, of which some 22 are found in America, 15 in Africa, and 7 in Asia; probably, however, some of these so-called species are mere varieties, due to differences of climate and soil. The most important are *Coffea Arabica* and *Coffea Liberica* (or *Liberiana*). The former is the well-known coffee shrub, and attains, naturally, a height of 15 to 20 feet. Its foliage resembles that of the Portugal laurel, and the flowers those of the jessamine, being small and white. The berries are first dark-green, changing through yellow and red to deep crimson.

Beneath the skin of the ripe berry is a glutinous saccharine pulp, closely enveloping the beans. These are usually two plano-convex seeds, but sometimes the berry contains one round seed which yields the "Peaberry" (or carracole) coffee of commerce. The silver skin adheres closely to the bean, the parchment more loosely.

C. Arabica flourishes between 36 N. and 30 S. lat., usually at elevations in sub-tropical regions. The most favourable temperature is 60° to 80° F., anything below 55° F. being unsuitable. A constant supply of moisture is also necessary. It flourishes in Brazil, Java, Ceylon, India, Central America, the West Indies, Arabia, Natal, and (recently) Australasia.

C. Liberica is a native of Liberia, and is distinguished from *C. Arabica* by a much more vigorous growth. It is affected less by disease than the latter, and may be much improved by cultivation. The produce is, however, coarse in flavour, and it is found advantageous to graft from *C. Arabica*.

Cultivation. — The surface soil must be good; the subsoil may be poorer, but should not be stiff clay. The best soil is perhaps that known in Brazil as "terra roxa," a top-soil of red clay 3 to 4 feet thick, with a subsoil of gravel. As a general rule, virgin forest land has been found most suitable; in the West Indies, ground where lance-wood, red-wood, and olive-wood grow is well adapted for coffee. In the selection of ground there are, besides, such factors as elevation, aspect, shelter from wind and rain-wash, temperature, rainfall, and proximity to water, to be considered. Shelter from wind is of the first importance, and should not be sacrificed for rich soil, as the latter can be obtained much quicker than the former. On flat land the cost of drainage is great, and a wet soil is fatal. Steep slopes are also unsuitable, on account of excessive rain-wash. Frost, of however short duration, is very injurious.

There are three principal methods of planting:—By seeds planted on the estate, a plan open to the disadvantage of weak and bad growths being unavoidable; another way is by transplanting young shrubs of 6 to 8 inches, selected from nurseries; the third and, according to some, the best method, is by means of branch-end slips. The trees are planted, according to locality, from 4 to 12 feet apart, that is, from 300 to 2,700 trees per acre. Where protection from sun and wind is necessary, some quick growing tree is planted between the rows, and round the confines of the plantation.

Pruning is practised to keep the shrubs at a convenient height for gathering the fruit, and to strengthen their lateral growth. Plantations are usually so situated that the surface soil is much washed away, and in spite of every effort to prevent this, a good manure is sooner or later necessary. The particular type varies of course with different soils, but well-rotted dung, with ground bones, is generally the best.

The coffee plant is liable to diseases and pests of several kinds. One is a leaf blight, due to the fungus *Hemileia vastatrix*, and consisting of yellow blotches which spread over the leaves, causing them to fall off. They suffer in a similar way from the attack of a fly or moth, and also from a leaf rot which covers them with a glutinous matter, turns them black, and also causes them to drop off. The tree trunks are subject to the action of a "borer" beetle, and bugs and canker also afflict the plant at times. The harvesting or picking of the fruit takes place as the berries ripen—that is, as they become red—and may last three months. As they are gathered they are conveyed to the curing-houses, and hence their further preparation proceeds in four stages—pulping, fermenting, drying, and classifying or sorting. The first of these operations consists in separating the beans from the enveloping pulp. This is done by machinery, the object being rapidity without injury to the beans. After pulping it is necessary to ferment the saccharine matter present, otherwise the "parchment" coffee would not dry. The beans are next dried in the sun, or by artificial heat, and at this point they are usually sent to port for shipment, where the shipper subjects them to a further sunning. The parchment and silver skin are removed and separated by winnowing, and then the beans are sorted according to size and shape by means of a "separator," which at the same time removes sand and dust.

The coffees in general use in England are Jamaica, Ceylon, Costa Rica, Brazil, Java, and Mocha.

Jamaica.—The cultivation of coffee in Jamaica dates back more than 150 years.

Sir N. Laws was the first person who planted coffee in Jamaica on a commercial scale, but he died in 1731, before the crop arrived at maturity.

In the following years several planters and merchants took the matter up, as they saw that coffee might become a profitable crop, if the duty could be made lower on its importation into Britain, solely on the ground of its place of origin.

Subscriptions amounting to £220 10s. were obtained from 22 subscribers towards covering the expense of procuring an Act of Parliament for lowering the duty on Jamaica coffee, and as these names may be of interest to the trade, they are given *in extenso* :—

List of Subscribers.

London, Anno 1732.

A list of the persons who subscribed and paid into the hands of Mr. Roger Drake and Co. the several sums undermentioned towards defraying the charges of an application for an Act of Parliament to encourage the planting of coffee in the island of Jamaica :—

	£	s.
John Ascough, Esq.	10	10
Thos. Beckford, Esq.	10	10
Jas. Dawkins, Esq.	10	10
Hen. Dawkins, Esq.	10	10
Messrs. Drake, Pennant, and Long	21	0
Thos. Fish, Esq.	10	10
Mr. Jas. Fitter	5	5
Cope Freeman, Esq.	10	10
John Gibbon, Esq.	10	10
Mr. Jn. Gregory	5	5
Capt. Joseph Hiscox	10	10
Mr. H. Lang and Co.	5	5
James Lawes, Esq.	10	10
John Lewis, Esq.	10	10
Mrs. Susannah Lowe	10	10
Samuel Long, Esq.	10	10
Chas. Long, Esq.	10	10
Messrs. Mayley and Gale	10	10
Valentine Mumbie, Esq.	10	10
Favele Peeke, Esq.	10	10
————————	10	10
Capt. Geo. Wane	5	5
	£220	10

In consequence of this agitation in favour of Jamaica, an Act was passed in the following year, entitled "An Act for encouraging the growth of coffee in the plantations in America." The duty was reduced from 2s. to 1s. 6d. per lb., and the exports from Jamaica in 1752 were 60,000 lbs., and in 1775, 400,000 lbs. The cultivation of coffee in this island is still continued, and for the five years ending July 31, 1887, the average acreage was 19,495; and the average quantity exported during the five years ending September 30, 1887, reached 61,350 cwt. per annum. It grows well almost anywhere on the island, but best at an elevation of 1,000 to 4,000 feet. Owing to the undulating surface any required altitude is available.

Ceylon.—Coffee seems to have been introduced by the Arabs, and to have been used for a long time in the adornment of temple gardens on account of its beautiful sweet-smelling flowers. Previous to 1868 it had become a lucrative industry, but the advent in that year of the *Hemileia vastatrix* dealt a blow to the trade, the effects of which, fortunately, have been somewhat mitigated by the subsequent introduction of tea-planting, cinchona cultivation, &c. The rapid development of these, arising, so to speak, from the ashes of the almost defunct coffee trade, will be seen from the following figures :—

Exports from Ceylon.

Tea :—		
1880	114,845	lbs.
1885	4,352,895	,,
1889	32,516,682	,,
Cinchona :—		
1876	16,842	,,
1886	15,000,000	,,
Coffee (average exports) :—		
1851—1855	387,240	cwts.
1856—1860	552,219	,,
1861—1865	721,405	,,
1866—1870	956,153	,,
1871—1875	851,895	,,
1876—1880	744,209	,,
1881—1885	380,145	,,
1886—1889	155,122	,,

Costa Rica.—Coffee was first planted here in 1796, at Cartago, and since the separation from Spain, in 1821, its production has been continuously favoured by the Government. Export duties have been repealed, model estates started, good roads made, and special privileges conferred on cultivators. That success has attended this policy is shown by the fact that this State exported 320,000 cwts. in 1884.

Brazil.—The celebrated fields of Brazil—Santos and Rio de Janeiro—are situated on a plateau of which the eastern edge is but slightly removed from the sea. Hillsides looking north are chosen as affording the greatest shelter from the cool south winds, and from the light frosts which occasionally occur during the winter months. Santos coffee, as a rule, is not so well cleaned as that from Rio, but the bean is usually larger, and of a better colour and aroma. Taken altogether, Brazilian is perhaps as good as any grown; indeed, it has been often sold in London, New York, Hamburg, and Amsterdam as "Old Government Java." Statistics of the quantity produced are somewhat meagre, but the annual amount is probably over 6,000,000 cwts.

Java ranks after Brazil in the amount of coffee produced. The culture is mostly in the hands of the Government, and effected by forced labour. Nurseries being very expensive and troublesome, a common expedient is to plant "stumps" from wild or casual seedlings. No pruning is done, and so the trees grow bushy, with several stems. Water is scarce in some parts, and in consequence the pulping and washing is performed by the labourers at home. After pulping, the beans are taken to a drying house, and dried over a slow wood fire, the reason for dispensing with the sun's heat being that a certain flavour is believed to be imparted by the wood smoke. The exports in 1878 exceeded 1,200,000 cwts., nearly all of which went to Holland.

Coffees are difficult to describe, but a few words on the best-known varieties may not be out of place. Their value depends largely on the distinctive flavour of the particular kind of coffee, and this flavour depends almost entirely on the roasting and cooling, and on the way the beverage is prepared.

Mocha is generally considered the finest of coffees. There are two varieties, the "long berry" and the "short berry." The former are greyish-yellow in colour, and give a rich mellow liquor. Mocha short berry is small and of a pale greenish-yellow tint; the infusion is similar to that of the long berry, but cleaner and more delicate.

Mysore is a good sized berry, bluish-grey, with more or less silvery covering; it yields a fine, strong, and clean liquor.

Ceylon Plantation is a fair sized, pale-greenish berry, gives a beverage with fair body, full, but smooth flavour, and very clean.

Costa Rica is a bluish-green berry, large and bold; yields a strong, useful, though somewhat coarse liquor.

Java is a very fine coffee, with large oblong berries, varying in colour from whitish to pale yellow and greenish. The liquor is strong and clean.

Brazil, although used to a considerable extent, has a peculiar, almost unclean, flavour; it is useful in mixing off with other kinds.

TABLE XIV.—ANALYSIS OF COFFEE.

	Mocha.		East Indian.	
	Raw.	Roasted	Raw.	Roasted
Caffeine	1·08	·82	1·11	1·05
Saccharine matter	9·55	·43	8·90	·41
Caffeic acids	8·46	4·74	9·58	4·52
Alcohol extract, containing nitrogenous and colouring matter	6·90	14·14	4·31	12·67
Fat and oil	12·60	13·59	11·81	13·41
Legumin or albumin	9·87	11·23	11·23	13·13
Dextrin	·87	1·24	·84	1·38
Cellulose & insoluble colouring matter	37·95	48·62	38·60	47·42
Ash	3·74	4·56	3·98	4·88
Moisture	8·98	·63	9·64	1·13
	100·00	100·00	100·00	100·00

The constituents of coffee which are of importance to the physiologist are the aromatic substances, the alkaloid caffeine, and the true food stuffs, viz., the carbohydrates, fat and soluble albumen.

The aromatic principles of coffee, whether natural to the berry or produced during the process of torrefaction, exert an exciting influence on the nerves of taste and smell, and thus indirectly produce an increased desire for, and enjoyment and digestion of, food.

The alkaloid caffeine is identical in chemical constitution, and therefore in physiological action with that of tea. Although the percentage of the alkaloid in the coffee berry is much less than in the leaf of tea, yet a cup of coffee, as ordinarily prepared, contains an equal if not greater quantity of the alkaloid than a similar cup of tea. The chief difference in the action of coffee and tea is due to the presence in coffee of the large quantity of true food stuffs, and the almost complete absence of tannin. The carbohydrates, fat, and soluble albumin impart a certain amount of nutritive value to coffee over and above the purely stimulant effect of the alkaloid common to tea and coffee. Also owing to the special character of its fatty substances, coffee has a slightly laxative effect upon the alimentary canal.

From these considerations, viz., that coffee is equal to tea in its stimulant effect on the brain and circulation, superior to tea in its influence on digestion, and that it is practically free from tannin, and does not therefore interfere with the assimilation of a meat diet, it can be understood how coffee had come into popularity as an after-dinner beverage, even before the chemist and physiologist had combined to demonstrate its superiority to tea for that purpose.

Chemistry of Coffee.—As before stated, coffee contains an alkaloid identical in composition with the alkaloid of tea, and called caffeine. It contains nitrogen as well as carbon, hydrogen, and oxygen, and has the chemical formula—$C_8H_{10}N_4O_2$.

It was at one time thought that the coffee berry lost much of this alkaloid during the roasting process, but this is not so. Paul and Cownley have made a long series of experiments on this subject, and the quantity present in the unroasted and roasted specimens they examined was from 1 to 1·3 per cent. The results obtained are as follow:—

TABLE XV.—CAFFEINE.

Kind of Coffee.	PER-CENTAGE OF		
		CAFFEINE.	
	Moisture.	Berries dried at 212° F.	Air-dried berries.
Coorg	8·0	1·20	1·10
Guatemala	8·6	1·29	1·18
Travancore	10·0	1 29	1·16
Liberian	8·0	1·30	1·20
Liberian	8·0	1·39	1·28
Rio	9·1	1·20	—
Santos	9·0	1·29	—
Manila	6·6	1·20	—
Ceylon	6·2	1·24	—
Perak	7 3	1·22	—
Costa Rica	7·2	1·24	—
Pale Jamaica	8·7	1·21	—
Mysore	8·0	1·28	—
Jamaica	9·0	1·28	—

The above results were obtained by the following method:—"The finely powdered coffee is mixed with moist lime, and percolated with alcohol. The residue left on evaporating the percolate is treated with water and a few drops of dilute $SO_2(HO_2)$, filtered, and the filtrate exhausted with chloroform, which on evaporation leaves the caffeine fit for weighing."

Roasted coffee contains about 1·3 per cent. of caffeine. From the above figures it appears that of all methods the surest, when examining coffee for adultertion, is the determination of the amount of caffeine.

There seems to be no appreciable loss of caffeine by volatilisation in the roasting of coffee when this is properly carried out. The data on which this opinion is based are collected in the following Table:—

TABLE XVI.

	Loss of weight in roasting.	CAFFEINE.		
		In raw coffee.	In roasted.	
			Found.	Calculated.
	Per cent.	Per cent.	Per cent.	Per cent.
Low roasted	13·7	1 10	1·30	1·28
Medium roasted	16·0	1·10	1·36	1·31
Over roasted	31·7	1·10	1 25	1·61

Of the loss of weight 8·22 per cent. was water expelled at 100° C.

ROASTING OF COFFEE.

The roasting of the coffee berry is an operation requiring great skill and judgment. Large dealers roast their own, and can command the necessary knowledge required for the proper performance of the work. Smaller dealers usually send their green coffee to be roasted at a general roaster's, as they have not the means to roast on the premises, and they thus run the risk of failure, or of getting other people's coffee for their own, which may or may not be an advantage, according to the circumstances of the case.

A good coffee roaster must understand the peculiarities of the different descriptions of coffee he has to roast. Some are tougher or more moist than others, and in such cases each kind must receive exceptional treatment. A perfectly-roasted berry is of a rich chestnut colour; it has lost its toughness and become crisp, so that it is readily disintegrated in the mill, and at the same time it has not a dark brown tint, which means that the coffee has been over roasted. Over-roasted coffee, however good its quality originally, is spoiled. It may give a darker liquor than if lighter roasted, but it possesses little or no aroma, and has had destroyed the natural constituents which make up the quality of good coffee.

Coffee when properly roasted will lose from 16 to 18 per cent. of its weight. A great part of this is due to the moisture which has been driven off by the heat; but the constituents of the berry have been also modified, as is shown in the Table XIV. ("Analysis of Coffee") showing the composition of the unroasted and roasted berry, and an aromatic oil has been produced which has an intense flavour.

A judicious blend of different kinds of coffee always produces a better liquor than any single coffee, but this mixture ought always to be made after roasting and not before. There is always a danger of the best green coffees, when imported, having been mixed with inferior qualities grown in the same district, and such mixtures will never roast well; but in roasting, different kinds should be treated separately, and then mixed before grinding.

The cooling of the roasted berry is also a delicate operation, requiring care and judgment, and if this operation be not properly performed, the best of coffee will be spoiled, and will produce a liquor of inferior quality.

When coffee is bought in bond, the general estimate is made that the cost of roasting will be from 2s. 6d. to 3s. a cwt., and that the loss of weight in roasting will be about 20lbs.; *i.e.*, 112 lbs. of raw coffee will yield 92 lbs. of roasted. This estimate is, however, a very wide one. In practice on a large scale, with gas for fuel, the cost for fuel and labour will not exceed 1s. 3d. per cwt., and the loss of weight will not exceed 17 lbs. per cwt. If the loss exceeds this amount the probability is that the coffee has been over-roasted, and will consequently have been deteriorated in aroma and delicacy of flavour.

As a nation we have been constantly blamed for our inability to appreciate good coffee, or to make it as skilfully as our French neighbours. The censure generally takes the form of a comparison between the habits of the two nations as to the roasting of coffee, the French roasting it in their own homes, and the English buying it from the grocer. It must be apparent, from the skill required in roasting coffee, that the home-roasting of small quanties must very often prove a failure, and no doubt this is often the case. But the fact remains that French coffee is popular, and that it stands high in comparison with the coffee supplied at English coffee-houses or hotels. After careful observation, I have come to the conclusion that by far the greater part of this popularity is due to the more liberal use of the coffee in making the beverage. Coffee, as compared with tea, is an expensive

TABLE XVII.—COFFEE.—UNITED KINGDOM.

	IMPORTS.						CONSUMPTION.	
Year.	Ceylon.	Other British Possessions.	Brazil.	Central America.	Other Countries.	Total.	Cwts.	Pounds per head.
	cwts.	cwts.	cwts.	cwts.	cwts.			
1873..	863,131	258,822	140,967	227,206	193,552	1,683,678	288,669	1·01
1874..	541,470	311,965	200,154	151,531	200,051	1,405,171	284,465	·98
1875..	755,715	242,097	224,453	210,908	160,983	1,594,156	290,413	·99
1876..	485,249	307,666	197,765	128,244	222,454	1,341,378	297,694	1·00
1877..	780,341	274,682	187,912	228,686	138,096	1,609,717	293,127	·97
1878..	509,154	269,917	200,998	156,544	136,797	1,273,410	298,154	·98
1879..	627,438	307,381	260,297	260,141	162,132	1,617,389	309,788	1·01
1880..	540,676	355,246	272,442	208,388	179,187	1,555,939	290,802	·94
1881..	326,728	241,766	266,756	198,087	179,395	1,212,732	285,209	·91
1882..	379,884	303,803	227,939	285,108	162,232	1,358,966	285,380	·90
1883..	227,378	261,945	403,966	191,779	313,160	1,398,228	289,715	·91
1884..	250,311	268,525	189,186	285,534	141,043	1,134,599	294,788	·91
1885..	245,444	235,978	192,098	221,194	140,896	1,035,610	298,306	·91
1886..	155,755	276,617	203,325	235,191	158,574	1,029,462	289,207	·88
1887..	133,996	185,236	300,495	245,344	181,141	1,046,212	268,322	·81
1888..	107,055	276,610	160,258	229,543	181,880	955,274	277,994	·83
1889..	56,595	182,565	382,423	223,810	195,213	1,040,606	259,279	·76

drink, and as the extract the roasted berry yields is comparatively small, the French have overcome this by using much more coffee than we do. It is on record that two or three cups of coffee thus prepared, and drunk quickly after each other, have produced effects similar to symptoms of poisoning, of a transient character it is true, but yet distinctly marked. The fashion for French coffee has led to many imitations in this country, and some manufacturers supply an article thus named. An examination of it shows that it has been roasted with sugar, and then, in almost all cases, mixed with a large proportion of chicory. Such a mixture gives great depth of colour, but when compared with the beverage made from pure coffee, and of the same depth of colour, the difference in aroma and flavour is most marked, and the counterfeit is easily detected.

The steady falling off in the consumption of coffee proves beyond question that coffee is not a popular drink. Its preparation for the table is much more complicated than that of its rival, tea, and as it is more expensive to prepare, it makes no progress in public favour, but rather loses ground. Fiscal regulations certainly favour it, but if the small duty were abolished altogether, there is no reason to believe that the consumption of coffee would thereby be increased to any appreciable extent.

Table XVII. (p. 1008) shows the imports and clearances for home consumption during the 17 years ending with 1889.

CHICORY,

Or succory, which is the prepared root of the wild endive, has had much to do with keeping down the consumption of coffee in this country. Originally a native of China, and introduced into Europe in the 16th century, it is now found growing wild in many parts of the continent and in this country. The root, which is large and fleshy, has when dried and roasted been much used as a substitute for coffee. It was at one time extensively cultivated in Yorkshire, but from Table XVIII., which follows, it will be apparent that the foreign-grown chicory is being substituted for that of home growth.

Chicory naturally contains a large quantity of sugar, some of which during the process of roasting becomes caramelised, and imparts to the chicory a bitterness similar to that natural to coffee. It also yields a large extractive, which coffee does not, and naturally coffee-house keepers and others have used chicory largely as an adulterant.

TABLE XVIII.—CHICORY.—IMPORTS AND CONSUMPTION.

Year.	Imports. Cwts.	Home grown. Cwts.	Consumption.	
			Total cwts.	lbs. per head.
1873...	116,492	9,131	104,746	·36
1874...	124,855	7,895	106,357	·36
1875...	106,656	5,549	99,807	·33
1876...	118,164	5,072	99,965	·33
1877...	112,072	4,704	104,187	·34
1878...	122,835	4,375	100,109	·32
1879...	123,373	3,311	109,302	·35
1880...	145,457	3,181	117,503	·37
1881...	143,697	2,365	116,350	·37
1882...	128,007	2,869	102,881	·32
1883...	127 781	2,[illegible]03	105,713	·33
1884...	119,355	2,952	100,958	·31
1885...	122,367	3,701	102,987	·31
1886...	117,999	4,449	102,249	·31
1887...	138,090	3,116	109,243	·33
1888...	116,059	2,906	103,319	·30
1889...	125,611	1,707	99,103	·29

Chicory also, till comparatively recent times, was not a taxable commodity, and the substitution of it for coffee was thus encouraged.

In December, 1832, the Lords of the Treasury stated that "no objections are to be made by the officers of Revenue to dealers and sellers of coffee keeping and selling 'chiccoree,' or succory, *unmixed* with coffee," but they would be liable to a prosecution if coffee was kept or sold mixed with "chiccoree," or succory, or any other article.

On January 20, 1840, attention was again drawn to the illegality of selling coffee mixed with chicory, but on August 31, in the same year, the Lords of the Treasury ordered that "No objection must be made on the part of the Revenue to dealers in and sellers of coffee mixing chicory with coffee, or to their having the same so mixed in their possession."

Such an order gave great dissatisfaction to the importers of coffee, and to all connected with a pure coffee trade, and at the same time the regulations pleased the coffee-house keepers and dealers in cheap coffee, who could with impunity substitute cheap chicory for the dearer coffee.

The authorities were, however, hampered in their movements by the fact that at that time there was not at hand any means accepted as reliable by scientific men for distinguishing chicory in the presence of coffee. Physical tests could be applied, and they would show that certain mixtures differed in their conduct with water from others whose history was known, but this deportment did not constitute legal proof. This question, and others of a similar nature, pressed heavily on the Revenue officials for settlement, and at this time the Inland Revenue Laboratory was established, principally for coping with the adulteration of coffee and tobacco.

Elaborate research into the composition and qualities of coffee and chicory was rewarded with success, and both by the microscope and by chemical and physical means the presence of the smallest quantity of chicory in coffee could be detected. The results obtained were referred for verification or otherwise to the best botanists and chemists of the day, and in 1853 reports were received from them which formed the basis of future legislation on the subject.

The facts obtained were then very interesting, and are so even now, and the following Tables, showing the deportment of chicory and other substitutes for coffee under examination, will satisfy even the sceptical that good work was done in this investigation :—

TABLE XIX.—WEIGHT OF SUBSTANCE DISSOLVED IN 2,000 PARTS OF WATER, TO PRODUCE AN EQUAL DEPTH OF COLOUR.

Caramel		1·
Mangold-wurzel		1·66
"Bouka" (a coffee substitute)		1·66
Sparke's vinegar colouring		1·74
Black malt		1·82
White turnips		2·
Carrots		2·
Chicory (darkest Yorkshire)		2·22
Parsnips		2·5
Maize		2·86
Rye		2·86
Dandelion root		3·33
Red beet		3·33
Bread raspings		3·64
Acorns		5·
Over-roasted coffee	mean 6·21	5·46
Highly-roasted coffee		5·77
Medium-roasted coffee		6·95
Another specimen of coffee		6·66
White lupin-seed		10·
Peas		13·33
Beans		13·33
Spent tan		33·
Brown malt		40·

TABLE XX.—COLOURING POWER OF VARIOUS SUBSTANCES DISSOLVED IN AN EQUAL QUANTITY OF WATER.

Caramel	1000·
Mangold-wurzel	602·4
"Bouka" (a coffee substitute)	602·4
Sparke's vinegar colouring	574·71
Black malt	549·45
White turnips	500·
Carrots	500·
Chicory (darkest Yorkshire)	450·45
Parsnips	400·
Maize	350·
Rye	350·
Dandelion root	300·3
Red beet	300·3
Bread raspings	274·72
Acorns	200·
Over-roasted coffee	183·15
Highly-roasted coffee	173·31
Medium-roasted coffee	143·88
Another specimen of coffee	150·15
White lupin-seed	100·
Peas	75·18
Beans	75·18
Spent tan	30·
Brown malt	25·

TABLE XXI.—SPECIFIC GRAVITY OF SOLUTIONS AT 60° FAHR.—1 PART OF SUBSTANCE TO 10 OF WATER.

Spent tan	1002·14
Lupin seed	1005·7
Acorns	1007·3
Peas	1007·3
Mocha coffee	1008·
Beans	1008·4
Neilgherry coffee	1008·4
Plantation Ceylon coffee	1008·7
Java coffee	1008·7
Jamaica coffee	1008·7
Costa Rica coffee	1008·98
Native Ceylon	1009·
Costa Rica coffee	1009·5
Brown malt	1010 9
Parsnips	1014·3
Carrots	1017·1
"Bouka"	1018·5
English chicory (Yorkshire)	1019·1
Black malt	1021·2
Turnips	1021·4
Rye meal	1021·6

English chicory	1021·7
Dandelion root	1021·9
Red beet	1022·1
Foreign chicory	1022·6
Guernsey chicory	1023·2
Mangold-wurzel	1023·5
Maize	1025·3
Bread raspings	1026·3
British Gum	1027·9
Gum Arabic	1038·6
Cane sugar	1040·9
Starch sugar	1042·8

TABLE XXII.—SUGAR IN COFFEE, BEFORE AND AFTER TORREFACTION.

		Sugar per cent.	
		Raw.	Roasted.
1	Plantation Ceylon	7·52	1·14
2	do.	7·48	·63
3	do.	7·70	0·0
4	do.	7·10	0·0
5	Native Ceylon	5·70	·46
6	Java	6·73	·48
7	Costa Rica	6·72	·49
8	do.	6·87	·40
9	Jamaica	7·78	0·0
10	Mocha	7·40	·50
11	do.	6·40	0·0
12	Neilgherry	6·20	0·0

TABLE XXIII.—SUGAR IN CHICORY AND OTHER SWEET ROOTS, BEFORE AND AFTER TORREFACTION.

	Sugar per cent.	
	Raw.	Roasted.
Foreign Chicory	23·76	11·98
Guernsey Chicory	30·49	15·96
English Chicory	35·23	17·98
do. (Yorkshire)	32·06	9·86
Mangold-wurzel	23·68	9·96
Carrots (ordinary)	31·98	11·53
Turnips do.	30·48	9·65
Beet-root (red)	24·06	17·24
Dandelion-root	21·96	9·08
Parsnips	21·70	6·98
"Bouka," a coffee substitute	—	5·82

TABLE XXIV.—SUGAR IN VARIOUS SEEDS, BEFORE AND AFTER TORREFACTION.

	Sugar per cent.	
	Raw.	Roasted.
Acorns	3·64	2·70
Horse beans	—	1·62
Peas (grey)	—	1·08
Maize	—	·82
Rye meal	—	1·96
Bread raspings	—	1·78
Lupin seed	—	·74
Brown malt	8·48	—
Black malt	—	1·66

TABLE XXV.—SILICA IN ROASTED COFFEE.

	Per cent. in ash.
Sample No. 1	0·
,, ,, 2	0·
,, ,, 3	0·26
,, ,, 4	0·2
,, ,, 5	0·17
,, ,, 6	0·28
,, ,, 7	0.
,, ,, 8	0·45
,, ,, 9	0·
,, ,, 10	0·
,, ,, 11	0·
,, ,, 12	0·09

Acting on the knowledge obtained, the Lords of the Treasury, on August 3, 1852, rescinded the order of August, 1840, and enacted that coffee dealers might keep and sell chicory, provided that it was sold separately from coffee, and in packages sealed or otherwise secured, and bearing a printed label with the name of the firm of the seller.

The trouble this regulation gave in its execution was so great that in the following year it was allowed (by General Orders, February 28, and May 13, 1853) that licensed dealers in coffee might sell chicory prepared and mixed with coffee, provided the package in which such mixture was delivered to the purchaser was labelled "Mixture of chicory and coffee," and that no finings or colouring matter, nor any substance or article whatever, except chicory, be allowed to be sold mixed with coffee.

Such a binding order compelled the executive of the Revenue Department to take action, and for about twelve years the adulterators of coffee were constantly prosecuted. The adul-

TABLE XXVI.—ANALYSIS OF THE ASH OF COFFEE AND CHICORY.

	Coffee.							Chicory.											
								Deducting Sand and Silica.				Deducting Sand and not Silica.				Not Deducting Sand and Silica.			
	Plantation Ceylon.	Native Ceylon.	Java.	Costa Rica.	Jamaica.	Mocha.	Neilgherry.	Darkest English (Yorkshire).	English.	Foreign.	Guernsey.	Darkest English (Yorkshire).	English.	Foreign.	Guernsey.	Darkest English (Yorkshire).	English.	Foreign.	Guernsey.
Potash	55·10	52·72	54·00	53·20	53·72	51·52	55·80	38·53	27·85	46·07	46·27	37·07	27·13	40·20	41·41	33·48	24·88	29·56	32·07
Soda	—	—	—	—	—	—	—	9·34	16·90	3·17	5·49	8·99	16·46	2·77	4·92	8·12	15·10	2·04	3·81
Lime	4·10	4·58	4·11	4·61	6·16	5·87	5·68	10·79	10·81	7·78	7·65	10·38	10·53	6·79	6·85	9·38	9·60	5·00	5·31
Magnesia	8·42	8·46	8·20	8·66	8·37	8·87	8·49	6·06	8·08	5·33	5·55	5·83	7·87	4·66	4·97	5·27	7·22	3·42	3·85
Sesquioxide of iron	·45	·98	·73	·63	·44	·44	·61	4·38	3·50	8·29	5·08	4·22	3·41	7·24	4·55	3·81	3·13	5·32	3·52
Sulphuric acid	3·62	4·48	3·49	3·82	3·10	5·26	3·09	11·38	11·78	8·38	8·67	10·95	11·48	7·32	7·76	10·29	10·53	5·38	6·01
Chlorine	1·11	·45	·26	1·00	·72	·59	·60	5·67	5·23	5·03	6·58	5·46	5·10	4·39	5·89	4·93	4·68	3·23	4·56
Carbonic acid	17·47	16·93	18·13	16·34	16·54	16·98	14·92	2·04	3·22	4·36	4·60	1·97	3·14	3·81	4·12	1·78	2·88	2·80	3·19
Phosphoric acid	10·36	11·60	11·05	10·80	11·13	10·15	10·85	12·27	12·61	11·00	9·59	11·81	12·29	9·60	8·59	10·66	11·27	7·06	6·65
Silica	—	—	—	—	—	—	—	—	—	—	—	3·81	2·61	12·75	10·52	3·81	2·61	12·75	10·52
Sand	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	9·32	8·08	23·10	20·19
Total amounts	100·63	100·20	99·97	99·06	100·18	99·68	100·04	100·46	99·98	99·41	99·48	100·49	100·02	99·53	99·58	100·85	99·98	99·66	99·68

teration could, however, be done so easily, and the mixture so readily disposed of, that the adulterator could afford to break through the regulations and run the risk of fines, and this was done to such an extent that in 1860 a duty of 3s. a cwt. was levied on home-grown chicory. This rate was in 1861 increased to 5s. 6d. and 8s. 6d.; in 1862 to 11s., later to £1 1s. 9d.; in 1864 to £1 4s. 3d., while the Customs' duty on foreign chicory was £1 6s. 6d. per cwt. In 1872 the duty was made less by one-half, on account of the coffee duty being reduced from 6d. to 3d. a lb. The practical equalisation of the duties on coffee and chicory in 1864 put a stop to Excise interference, as the substitution of one for the other was no loss to the revenue. The poor consumer was thus deprived of his protector, and remained at the coffee dealer's mercy until the public analyst rose up to protect him. The analyst's powers are not, however, very great, and do not extend beyond making it an offence to sell coffee containing chicory for pure coffee. The quantity of chicory which may be added is not subject to legal control, and, therefore, the consumer can be to any extent defrauded by the substitution of chicory for the more expensive coffee, and he is powerless to protect himself. The skilful vendor of these mixtures is careful to roast his coffee with sugar, which sugar becomes caramelised during the roasting, and the clear bitter flavour of the caramel thus introduced masks the earthy taste of the chicory which, when present in large proportions, imparts to the coffee (so called) a full, earthy, mawkish flavour. Such mixtures of coffee, burnt sugar, and chicory are now generally sold in tins, under the name of French coffee. These mixtures containing large quantities of chicory must be preserved in tins, for if exposed, the chicory and caramel quickly absorb moisture, on account of their hygroscopic properties, and become clogged into a mass, which soon runs into decomposition. The tinned coffee of 35 years ago was eagerly purchased because of its cheapness and handiness for consumption, but the consumer thought not how very little the mixture was intrinsically worth, or that though apparently cheap, yet the profit actually made out of it was sufficient to place the manufacturer of it in a position of affluence in a very short time. The imposition of a chicory duty somewhat curtailed the profits made on tinned coffee, but sufficient profit now remains to make the trade a very lucrative one, and to place the sale of coffee and its twin sister, tea, in the highest position of importance for profit among the goods vended by the family grocer.

In 1882 the duty on coffee and chicory was retained, but the same rate of duty which had been imposed on "other vegetable matter applicable to the uses of chicory or coffee" was repealed, and in its place a duty was levied on all imitations of coffee or chicory and on coffee mixtures.

This duty was to be secured by stamp labels attached to packets of certain weights, and it was expected that many substitutes which before had escaped duty would in this manner be brought to charge. The result has not answered expectations, for since the imposition of the label in lieu of the old duty the receipts have steadily declined, as will be apparent from the following official return:—

TABLE XXVII.

Year.	½d. labels.	1d. labels	Net amount received.		
			£	s.	d.
1882-3......	1,440,305	802,434	6,344	2	2½
1883-4......	1,432,203	645,429	5,673	0	10½
1884-5......	1,110,664	539,893	4,563	8	9
1885-6......	1,021,868	446,525	3,989	8	3
1886-7......	799,914	370,971	3,212	4	0
1887-8......	704,862	332,921	2,855	12	8
1888-9......	670,050	309,828	2,686	17	9

Chicory, which is generally employed as a substitute for coffee, has been frequently adulterated in its turn by the addition of cheap substitutes. The following illustrations will give an idea of the manner in which the fraud has been carried on. A chicory roaster, who was also a mustard manufacturer, used up in his roasted and ground chicory all the husks of the mustard seed employed in making mustard, and when detected his excuse was that the husks were not added for adulteration, but simply to assist the roasting of the chicory. These husks were absolutely worthless as mustard husks, and they only became of value when substituted for chicory. Another similarly used roasted grain, and another the common biscuits known in the trade as dog biscuits. In all these cases the same excuse for their use was made, namely, that the substances added were to assist the roasting of the chicory. It is only proper to remark that these ingenious people always found the defect of the chicory remedied by the addition of a much cheaper substance, and never by that of a dearer one.

Not many years ago a sensation was caused in the coffee trade by the sale of roasted ground acorns as a substitute for coffee, and this rubbish, under the name of "Pelotas Coffee" and "Coffee Surrogate," was extensively advertised as a superior coffee substitute, possessing certain desirable qualities not found in coffee.

Later on an ingenious utiliser of waste products had his attention directed to an accumulation of date stones, obtained from the dates used at a distillery in the north of England for the manufacture of alcohol. These worthless stones were removed to a large manufacturing town, roasted, and presented to the public as "Date Coffee." The extractive produced from the roasted stones was exceptionally low, but the Stock Exchange speculator ran up the £5 shares of the company to about five times their value, and those behind the scenes took care to be cleared out of shares when the crash came. The worthlessness of the article was soon proved, and the company has long since gone into liquidation. It is well established, from the test of experience gained in Great Britain, and in continental countries in which coffee is in use as a general beverage, that the best of all coffee substitutes is roasted chicory. It lends itself more readily as a good substitute than other vegetable substances, by rapidly giving up in decoction its extractive matter, which imparts a dark colour to the mixture in which it enters, and thus covers the naturally poor extractive obtained from coffee. Being not in the slightest degree injurious to health, it cannot be condemned as unwholesome, and many prefer a mixture of coffee and chicory to pure coffee itself.

In addition to this, the difference in price between the poorest commercial coffee and the best chicory is very great, and, consequently, both price and flavour offer a strong inducement to add chicory to coffee. This inducement to add chicory can be shown in a very simple manner by reference to Table XX., p. 1010.

It will be seen that 6·21 lbs. of coffee, and 2·22 lbs. of chicory are equal to each other in tinctorial power, and that 1 lb. of caramel is their equivalent in this respect. One pound of chicory will therefore be equal in colouring power to 2·8 lbs. of coffee. The price of chicory is about 3½d. per lb., and the average price of roasted coffee may be fairly taken at 1s. 5d. At this rate the colouring power derived from 1 lb of chicory of the value of 3½d., is as great as from 2·8 lbs. of coffee of the value of 3s. 11d. It may be urged that other properties of coffee have to be considered beside the colour of the aqueous extract, and there is force in this contention, but with the frequenter of the coffee tavern, the standard of quality of coffee is its colour, and even at hotels of ordinary repute, colour rather than quality is apparently the standard of the ordinary coffee consumer.

The dealer well acquainted with his business knows from experience the quantity of chicory every description of coffee will carry before deterioration of taste and flavour is pronounced, and to this judicious admixture in suitable proportions can be attributed the success of certain firms who have made ground tinned coffee a specialty.

The coffee trade is, however, a declining one, as has been shown from the imports for consumption, and whilst some consider that the legalising of mixtures has led to this decline, others believe that the dearness of coffee, as compared with tea, and the trouble of preparation, have been the main causes which have led to its diminished consumption.

Miscellaneous.

AGRICULTURE IN BULGARIA.

Bulgaria is an almost exclusively agricultural country, and this statement will be found to be fully borne out by the statistical returns of the country's exports. Besides grain, Bulgaria produces wine, silk, tobacco, attar of roses, and, in some prefectures, rice and cotton. But everything, says the British Vice-Consul at Sofia, in spite of the endeavours of the Government, remains in an absolutely primitive condition. The Bulgarian peasant is slow to take up new methods, and looks on all such with jealousy and suspicion, although he is practical enough to adopt them when fully convinced of their advantages. Unfortunately, his distrust of newfangled agricultural appliances and implements has been increased, by the fact that such experiments as he has seen carried out have too often failed through improper use of the machines imported, through these being unfit for the country or nature of the work, or through lack of experienced men to work the machines or effect any slight repairs requisite. The Bulgarian peasant follows ancestral traditions; he goes on sowing the same field for three or four years in succession with the same crop. Experience has taught him that it will then be necessary to let it lie fallow for two or three years, and that after that only light crops can be expected for some time. Meanwhile he has till now been in the habit of clearing a tract of forest land, knowing that for the first few years it will be fertile, though the action on the soil of the dead leaves and decayed branches; but he is innocent of any idea of the rotation of crops, and scarcely less ignorant of the beneficial effects of manure. He is equally careless of his meadows and his pasturage. The Government is very zealous in its attempts to improve by all possible means the state of agriculture in the country. The absence of good roads between villages and the neighbouring towns has for some time past occupied the attention of the Government, and some progress has of late years followed. Model farms have been attached to the agricultural schools of Sadovo (prefecture of Philippopolis) and Roustchouk; these schools are attended respectively by ninety and seventy pupils, almost all of whom are Government stipendaries. The total annual cost of the two schools, farms, &c., is about £10,000. Seeds of improved grasses, clover, oats, rye, colza, and the best qualities of tobacco, are almost every year distributed by the Ministry of Finance to the prefects, and by these throughout the villages. Travelling agricultural instructors are to be appointed, and a practical school of agriculture founded in every prefecture. The price of agricultural land varies in different parts of the country from 16 francs to 80 francs the deunum, or £2 10s. to £12 per acre; the land owned and cultivated by the average peasant proprietor is from 15 to 100 deunums, or 3½ to 25 acres. The average return of grain is 107 kilogrammes per deunum, or slightly under 8 cwts. to the acre. The area of vineyards under cultivation is 178,500 acres; the estimated production of grapes is 7,013,000 cwts. The greater part is made into wine and consumed within the country. Probably the wine industry is the most primitive of all, no care being taken to select the proper moment for picking the fruit, or the proper fruit to pick; nor is the necessary cleanliness observed in the presses and vessels. Vice-Consul Blech says, however, that when due progress has been made in the art, viticulture will rank high in the scale of Bulgarian agriculture, and there is no reason, either in point of climate or soil, why some day the most celebrated vintages of France should not be rivalled by Bulgarian vineyards. There are 6,500 acres devoted to tobacco cultivation, which produce about 36,000 cwts. This branch of agriculture is a fairly flourishing one, and the Government has sought to improve the quality of the leaf by distributing seeds and cuttings from the famous Yenije district. The cultivation of roses and production of the famous attar is carried on chiefly in the prefectures of Philippopolis and Eski Zara, in the latter of which the well-known Kezanlik valley of roses is situated. The annual output is about 600,000 miskals, or, approximately, 6,000 lbs. avoirdupois of attar of roses; the value is from 3 to 3½ francs per miskal (£12 to £14 per lb.). Rice culture is carried on, to any extent, only in the prefectures of Philippopolis and Tatar Pazarjik. On the creation of Eastern Roumelia this branch of agriculture was prohibited by law as being injurious to public health, but since 1885 the culture has again been allowed. Government duties of about £2 per acre are paid for the fields cultivated; the annual yield is about 37,000 cwts. Some twenty years ago silkworm rearing was an important branch of industry, as is still attested by the numerous plantations of mulberry trees to be found in various parts of the country; but owing to disease among the silkworms, it had almost entirely died out. Of late years some revival has taken place, and the production is considerable in the southern prefectures. The silk is much used for local requirements, and about £30 000 worth is annually exported, chiefly to Italy. Flax, hemp, poppies, madder, and in some parts of Eastern Roumelia cotton are all cultivated. The Government has also sought to popularise the cultivation of colza, and in certain districts with success. Farm labourers are usually paid by the season, from early spring to winter; the wages are usually from £10 to £12, food and lodgings being provided, and in some cases clothing. The cattle found in Bulgaria are horses, bulls, oxen, cows, buffaloes, sheep, goats, and pigs. Oxen and buffaloes are almost invariably the draught animals employed, especially in agricultural work. Until quite recently nothing has been done to improve the breed of cattle, or even to preserve it from deterioration, but the Government is striving to effect an improvement. Stallions of the best breeds are being procured from Hungary and distributed throughout the country; bulls from the Vratsa, Rahovo, and Plevna districts—the best in Bulgaria—have been purchased by municipalities, and placed at the disposal of villagers; and the Karnolod sheep, renowned alike for their flesh and their wool, are recommended as furnishing a sufficient means of improving the quality of sheep in the country. In 1888 the number of sheep, goats, and pigs in Bulgaria were respectively 6,872,000, 1,204,000, and 395,000.

CARPET MAKING IN SYRIA.

Consul Bissinger, the United States Consul at Beirut, says in his last report that carpets in Syria are exclusively made by peasant women and girls residing in villages situated within the political subdivisions known as Hakkar, Hossu, Safita, and Hazzoor, in the Mutessarrifiate of Tripoli. The most important of these villages—about a dozen in number, is that of Haidamoor, about thirty miles east of Tripoli, which appears to excel all others in the quality, durability, and design of the carpets it produces. There is also a good quality of rugs made in a village called Fakeh or Fiki, which are placed on the market at prices ranging from 32s. to £5 each. Fakeh is distant about 25 miles from Baalbek, and politically belongs to the district of the same name in the vilayet of Syria. Power looms do not exist in Syria, and though it is not possible to exactly ascertain the precise number of hand-looms, it may, it is said, be approximately stated as about 350. They are of the simplest construction, and may be described as follows:—Small pegs, to which yarns of desired colours are attached, are driven close together into the ground. The yarn is carried along the ground the required length, and fastened to a corresponding row of pegs. Beginning at the left hand, the threads are separated with a strip of board of various widths, generally, however, about four inches, which permits the tossing of a ball of the woof; no shuttles are used, a simple ball of yarn replacing them. This board is then advanced about a foot, and turned on its flat side, the operator taking a coarse wooden comb to bring the woof together, a long and tedious process. One operator can scarcely make more than three or four inches of carpet per diem; but if she is exceptionally clever at her businesss, she may succeed in accomplishing six inches. To make the average sized carpet of three *pics*, or two and a quarter yards long by one and a half wide, would require at least six weeks of continuous or uninterrupted work, which is not possible, as the operator is a woman who has domestic duties to perform, besides devoting mach time to field labour, such as sowing, reaping, &c., at certain seasons of the year. Every loom has a female attendant or worker, who is sometimes assisted by a young girl, and the carpet industry in Syria is exclusively in the hands of women. Most of the rugs are made with a small square of some decided colour, generally blue upon a black ground, placed in a very conspicuous place, intended to ward off the "evil eye." All the carpets produced in Syria are made of pure wool of the ordinary quality grown in the country. The number of persons engaged in carpet making in the Tripoli district is uncertain, but it probably does not exceed 500. As there are no factories, and every woman works on her own account, no wages are received or paid; the assistant, if more than one person is engaged upon a single loom, generally being the child of the operator. Fairs are periodically held in Calaat-el-Hosson, notably on "St. George's Feast" (April 23), on the "Feast of the Cross" (September 14), where merchants from Tripoli, Homs, and Hamath, come to make purchases. To these fairs the husbands, brothers, or other relatives of the women operators bring their rugs, where they are readily disposed of at prices much below those that are usually asked of brokers, who sometimes travel to the villages where they are made, expecting to secure bargains. Unless picked up by tourists in their travels along the coast, these rugs are exclusively marketed in Turkey by merchants from Tripoli, Homs, and Hamath. The rugs made at the present day are of very inferior designs, as compared with the ancient ones; the prevailing colours are usually red and black, varied occasionally by crimson and black, with black or dark brown figures at both ends. In one village, distant about ten miles from Haidamoor, the colours which predominate are red and green, with white borders, having white circles about two inches in diameter, with either green or red centres. A rude sort of carpet is the specialty of another village; it is from twenty to thirty feet long and four feet wide, made in stripes about two inches wide, of a brown colour, alternating with a dingy yellow, black, and a dirty white, the white and black being the natural colours of the wool. The deterioration in design may be due, says Consul Bissinger, to the fact that the rug makers use no pattern to guide them, depending entirely upon memory, often treacherous, and being a simple, uneducated people, they have gradually but irretrievably lost the original art. Until quite recently a beautiful rug of a brown or velvety black was manufactured, but it is no longer to be seen. The colour with which to dye the wool was obtained by digging shallow holes in winter streams. In the spring or summer, when the streams were dry, the peasants removed the earth collected therein, which, after repeated washings, produced a beautiful and indelible pigment. The custom has now utterly fallen into disuse, because cheap colouring matter can be secured from France. This has greatly deteriorated the quality, beauty, and durability of the rugs, and lessened their commercial value correspondingly. Blue, green, red, old gold, orange, and other colours were formerly extracted from roots, leaves, and barks of trees in the most primitive manner, but the introduction of cheap dye stuffs has now completely superseded them. Rugs vary in size from two feet square to four feet wide by twelve feet long.

BAMBOO FIBRE.

A memorandum, together with a sample of the plant, lately received from Sir Alfred Moloney, K.C.M.G., the Governor of Lagos, gives an account of the endeavour he is making to encourage the exportation of the fibre known as "African Bass," the fibre of the bamboo palm ,or *raphia vinifera*. The "bamboo" palm, or *raphia vinifera*, is perhaps the commonest tree in the swamps and low lands which line the waterways of the colony. Dense thickets of these palms, traversed only by the palm wine gatherer or the bamboo cutter, push their way into the lagoons, and extend over the flood grounds, and even to a distance of from 15 to 20 miles up the river valleys into the interior. The area occupied by these *raphia* forests it would be impossible to calculate, but it may be accepted without doubt that they extend throughout the length of the colony, and to a distance of at least fifteen miles from the sea coast, and that over this area of about 5,000 square miles they form a considerable proportion of the vegetation; next only in numbers to the oil palm, *elaeis guineensis*, and the mangrove, *rhizophora mucronata*. The fibre itself is the one in most common employment on the coast, being used by the natives for all sorts of purposes—cloth, cordage, thatch, fishing lines, &c. The cost is only that of collection and preparation, the latter being a very simple process of soaking and scraping. The price, delivered in England, is said to be £30 to £32 per ton for good fibre. The cost of production is estimated at £14 per ton, shipping and other expenses at £4 10s. The samples are now on view at the Society's House, and can be inspected by anybody desirous of doing so.

Notes on Books.

THE LIFE STORY OF OUR EARTH. THE STORY OF EARLY MAN. By N. D'Anvers. London: George Philip and Son. 1890.

Both these little books belong to a series entitled "Science Ladders," intended as first books in science for young readers. The first-mentioned is an elementary geology, intended to convey in simple form a general notion of the science, and the principal conclusions to be derived from it. The second gives a brief account of primeval man, and of what is known about him, beginning with a summary of the work of Boucher de Perthés and his successors, and passing by the Swiss lake-dwellers to the mound-builders and cliff-dwellers of Armenia, and concluding with a description of the pre-historic buildings of Central and South America.

Obituary.

SIR RICHARD FRANCIS BURTON, K.C.M.G.—Sir Richard, better known as Captain Burton, whose death at Trieste, on the 20th inst., is announced, was a member of the Society of Arts from 1875 to 1884, and a contributor to the *Journal*. In 1878, he read a paper before the Society on "Midian and the Midianites," and in 1882, one concerning "Gold on the Gold Coast;" for the latter paper he received the Society's silver medal. Sir Richard was born on March 19, 1821, and his remarkable exploring career commenced in 1852, when he undertook, in the disguise of a Pathan, a journey to Medina and Mecca. He was the first pioneer in Central Africa, and the discoverer of Lake Tanganyika. He was appointed by the Foreign Office Consul at Fernando Po in 1861, and after holding the same office at Santos, and at Damascus, he was, in 1872, appointed Consul at Trieste, where he remained until his death. In 1886, he was created a Knight Commander of the Order of St. Michael and St. George. His works, consisting of travels, translations of the Lusiads of Camoens, and of the "Arabian Nights," as well as collections of tales, &c., were numerous.

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Proceedings of the Society.

CANTOR LECTURES.

SUGAR, COFFEE, TEA, AND COCOA, THEIR ORIGIN, PREPARATION, AND USES.

By Richard Bannister.

Lecture III.—Delivered May 12th, 1890.

Tea: its History.

The tea of commerce consists of the leaves of a hardy shrub which is often found growing in conservatories in this country, and even in the open air in sheltered and favoured situations. It, however, is not a native, and the climate most suitable to its growth is found between the 25th and 23rd degrees of north latitude, and the 115th and 122nd degrees of east longitude. This habitat is given simply because when tea came into repute it was cultivated in the particular locality named as an article of commerce, but the plant flourished in other districts where it was not tended as of any commercial value. The tea plant, no doubt, came into popularity when it was cultivated in China only, and the first accounts we have of the use of tea as a beverage certainly fix China as its place of origin.

A learned Chinese, who lived a thousand years ago, said of the infusion of tea that—

> " It tempers the spirits and harmonizes the mind;
> Dispels lassitude, and relieves fatigue;
> Awakens thought and prevents drowsiness,
> Lightens or refreshens the body, and clears the perceptive faculties."

Giovanni Botero, an Italian author of repute, mentions in his book on the causes of magnificence and greatness of cities that "the Chinese have a herb out of which they press a delicate juice, which serves them for drink instead of wine; it also preserves their health, and frees them from all those evils which the immoderate use of wine produces among us."

The Dutch East India Company, twenty years later, 1610, introduced tea into Europe, and it is said to have been first imported into England from Holland about the year 1650. As soon as imported it became a fashionable drink amongst the leaders of society, and it is on record that certain members of the aristocracy, interested in its importation, used their influence in their own immediate circles to introduce the new beverage. Their efforts appear to have been successful in a way which they probably did not intend, for in 1660, when coffee-houses were only just established in London, an Act of Parliament came into force which imposed a duty of 8d. on every gallon of "coffee, chocolate, sherbet, and tea made and sold." In Samuel Pepys's diary, he enters, "September 25, 1661, I sent for a cup of tea (a China drink), of which I had not drunk before." As Mr. Pepys held the official position of Clerk of the Acts (Navy-office), he would not have made such an entry if tea had entered into ordinary use as a beverage.

In 1662 Charles II. married the Princess Catherine of Portugal, who liked tea, and in 1664 the East India Company bought 2 lbs. of tea as a present for the king; three years later, they directed their agent at Bantam to send home 100 lbs. weight of the best tea he could get. The consumption of tea considerably increased, and the method of levying a duty on the infusion, and not on the commercial article itself, was soon found to be impracticable in its incidence. There was no definition of the strength of the infusion, or relation between the water used and the tea, &c., employed, laid down in the Act of Parliament imposing the duty, and as an improvement it was enacted in 1689 (Act I. William and Mary), that an excise duty of 5s. a pound should be imposed on the tea itself.

Considering that tea was an importation of very recent date, it evidently came speedily into notoriety for fiscal purposes, and as it appeared to be the drink of the rich on account of its price, little harm was done at the time in making it subject to a heavy duty. In time, however, the fashion of tea drinking extended, and as tea was a beverage which refreshed and stimulated without clouding the mind as intoxicants did, its use became more general, and the demand for it was only limited by its price and the difficulty of obtaining it.

Before it was thoroughly established as a beverage, it had to encounter much prejudice, on account of tea being of foreign growth, and the fashion of tea drinking a foreign one. Jonas Hanway was a fair specimen of the opponents of tea, and in 1707 he published an "Essay on Tea, considered as pernicious to health, obstructing industry, and impoverishing the nation." Some advocates of tea drinking had stated that tea cured and prevented scurvy; but Hanway said that the sailors referred to "owe their health to rest, to sailing with a trade wind, to rice and other kinds of farinaceous foods, and not to tea."

A specimen of his style of declamation may be interesting, as well as amusing: the following is therefore given as an illustration:—

> "Will the sons and daughters of this happy isle—this reputed abode of sense and liberty—for ever submit to the bondage of so tyrannical a custom as drinking tea? Must the young and old and middle-aged, the sickly and the strong, the poor and rich, in warm weather and cold, in moist and dry, with one common consent, employ so many precious hours in so low a gratification as drinking tea?
>
> "Custom is said to be a second nature—in many instances it is a first—but as we shall never walk on our hands so conveniently as on our feet, I am persuaded the inhabitants of this island will never increase in number, or enjoy a blooming health, whilst they continue such an extravagant use of tea."

After dwelling on the force of fashion with regard to tea, he answers a fair correspondent, whom he assures—

> "It is in your power to destroy this many-headed monster, which devours so great a part of the best fruits of this land."

And if successful, the inscription on the statue to be erected to her memory shall run thus:—

MDCCLV.
To
the remembrance
of the fair Guardian Spirits of
Britain,
whose influence and example
abolished the use of
a Chinese drug called
TEA;
the infusion of which had been for many years
drank in these realms and dominions,
injuring the health,
obstructing the industry,
wasting the fortunes,
and exporting the riches
of His Majesty's liege subjects.
etc., etc.

The Dutch, in the 17th and 18th centuries, were our great competitors in the East, and whilst we had a chartered company known as the East India Company, the Dutch had their chartered company also, which had a more direct trade with China than the British company and had better opportunities of opening up a tea trade with China and the countries adjacent. The result of the competition was that the Dutch company brought tea to Europe for consumption, and as it presented no difficulty in storage for smuggling, it was largely imported into this country by the smuggler, and the duty was thus evaded. This state of things could not, for fiscal reasons, be long tolerated, and to modify the injury done to legitimate trade, it was thought desirable to reduce the duty and thus curtail the profits of the smuggler. Before 1745, tea was charged with an excise duty of 4s. per lb., and an *ad valorem* duty of customs of 14 per cent. In that year, on a recommendation of a special committee of the House of Commons, the duty was reduced to 1s. per lb. and 25 per cent. *ad valorem*. These two, when taken together, made the duty about half what it was before.

The effect of this change was soon apparent; the clearances for duty at once increased, this result being due not so much to increased consumption as to obtaining from a legitimate source a portion of the tea which had before been supplied by the smuggler's agency. McCulloch gives figures to show the extent to which smuggling was carried on as a consequence of the high duties. He states that "in the nine years preceding 1780 above 118,000,000 lbs. of tea were exported from China to Europe in ships belonging to the continent, and about 50,000,000 in ships belonging to England. But, from the best information obtainable, it appears that the real consumption was almost exactly the reverse of the quantities imported, and that while the consumption of the British dominions amounted to above 13,000,000 lbs. a year, the consumption of the continent did not exceed 5,500,000 lbs. If this statement be nearly correct, it follows that an annual supply of about 8,000,000 lbs. must have been clandestinely imported into this country in defiance of the Revenue laws." After making the fullest allowance for errors that may have crept into this estimate, it cannot be denied that smuggling must have been carried on on a very large scale, and that the legitimate trader must have been sorely pressed by the fraudulent one. In fact, the Statute-book bears evidence of the prevalence of fraud on the revenue, for the Act 10 Geo. I., cap. 10, which came into force at Midsummer, 1724, empowered the officers for inland duties to enter any warehouses, storehouses, rooms, shops, cellars, vaults, and other places made use of for keeping or making any coffee, tea, cocoa-nuts, or chocolate, and by weighing, gauging, or otherwise to take an account of the quantities and sorts of the said commodities which shall at any time be in their or any of their custody, and each proprietor was compelled to keep sufficient scales and weights necessary for the taking of stock, and to render every assistance to the public officer when so employed.

In the following year—1725—legislation was directed to protect the revenue from fraud by the counterfeiting or adulteration of tea, and from altering, fabricating, or manufacturing tea with *terra japonica*, or with any drug or drugs whatsoever. It was also made penal to mix, or cause or procure to be mixed, with tea any leaves other than leaves of tea, or any ingredients whatsoever, under the penalty of £100. And to make this matter more stringent, as well as to cultivate a feeling of insecurity in those practising this system of adulteration, it was enacted that half the fine recovered from the offender should be given to the informer.

In the reign of George II. (4 Geo. II., c. 14) there were persons ill-disposed enough to the Revenue to manufacture sloe, liquorice, the leaves of tea already used, and the leaves of other trees in imitation of tea, and this was also made a penal offence.

The Act 17 Geo. III., c. 29, shows, from the elaboration of the statements made in that of George II., that tea adulteration was increasing both in amount and ingenuity, and it was thereby enacted that "any person who, after June 1, 1777, shall dye or manufacture in imitation of tea any leaves of tea that have been used, or any sloe, liquorish, or elder leaves, &c., or shall sell or offer to sell the same, shall on conviction forfeit £5 for every pound of such leaves so dyed." A penalty was also incurred by persons having in their possession more than six pounds of any such leaves, and not satisfactorily accounting for the same. Power was also given to enter suspected premises by special warrant to search for such adulterants, and if found they were to be destroyed. A novelty was also introduced into this Act as to the appropriation of penalties recovered. One half was to be paid to the informer, and the other half to the poor of the parish in which the offence was committed. These Acts of Parliament throw a somewhat lurid light on the state of society at the time they were enacted. It is evident from the preambles of the Acts that not only was smuggling very common, but that factories were established in remote places to supply the public with imitation tea. Such factories would never have come into existence if there had not been a demand for the goods manufactured in them, nor would there have been set up such ingenious methods of making the general public detectives if the illicit manufacture of imitation teas had not been widespread. Such enactments show conclusively that the true method of taxation is to impose only such duties as articles will legitimately bear, excessive rates leading, as a matter of course, to smuggling and other irregularities. With the reduction of the tea duties no new regulations have been found necessary, and beyond a special departmental examination by the Customs of tea on importation, nothing further has been done to protect the Revenue. From 1844-1856 a large number of samples were examined, and 137 selected for analysis. Of these 68 were adulterated. There were two classes of adulterated tea—the "lie teas" prepared by the Chinese, and the spurious teas manufactured in this country. In the former the following substances have been found:—Gum, indigo, vegetable yellow, Prussian blue (rare), carbonate of magnesia, sulphate of lime (rare), silica and dextrin (very rare). In the latter class have been found exhausted tea leaves, and the leaves of beech, elm, plane, poplar, oak, and willow, made up to represent green tea with some of the following:—Gum, Dutch pink, Prussian blue, indigo, carbonate of magnesia, French chalk, and sulphate of lime; and slightly coloured with rose pink to impart a bloom to represent black tea.

The Food and Drugs Act, which embraces within its folds the adulteration of all articles of food and drink, has remained practically a dead letter regarding tea, as no imitation tea has been found, and tea as imported is almost invariably genuine.

EAST INDIA COMPANY'S MONOPOLY.

What was done for the cultivation of tea in China before it was known to Europeans we are unable to learn, except that Moorish travellers related that in the 8th century Mahometans had free ingress and egress as to China, and that at the time named the general drink of the people was prepared by immersing the leaves of a small plant in hot water, which was used medicinally and to correct the bad qualities of the water; and from the scraps of history which are available we gather that the wars of Europe had much to do with opening up our Eastern trade.

The Portuguese, the prominent navigators of the 15th century, found a way to India by the Cape of Good Hope in 1497, and for nearly 100 years they had possession of the commerce of that part of the world. When they perceived that it was desirable to have undisputed possession of this proverbially rich territory, they endeavoured to secure a monopoly in a very cheap way, and this for nearly a century was as successful as if they had depended solely on the strongest of fleets and armies to ensure the success of their plans. Soon after they had made important discoveries on the West Coast of Africa they applied to the Pope for a bull to confer on them the "exclusive right to, and possession of, all countries occupied by infidels which the Portuguese either had discovered or might discover" to the south of a certain point of latitude (27° 54′ north). The Pope granted the bull, and the Portuguese were left in possession till the war broke out between Philip II. of Spain and the Low Countries. The Dutch then, wishing to cripple the power of their enemy abroad as well as at home, began to dispute the rights of the Portuguese in the Indian seas; and the English, who had been trying to avoid a rupture with the Pope and Portugal, having fruitlessly endeavoured to discover a northern passage to the East, at last went on the same lines as the Dutch, and treated the Pope's bull with defiance both at home and in foreign lands. The great naval engagements fought between the English and the Spaniards (the Spaniards having conquered Portugal in 1580) led to the destruction of the Spanish navy, and some of the Spanish East India merchantmen which were captured contained such quantities of silks, spices, calicoes, gold, precious stones and gems, that the cupidity of the English adventurer was stirred, and it was determined to open up the treasures of the East by English enterprise and capital,

For the protection and national recognition of those engaged in the trade it was thought desirable that the adventurers engaged should form themselves into an association having special and exclusive privileges. They applied to Queen Elizabeth for two things. First, for a charter of incorporation, and secondly, for the right to exclude any person from trading in any form whatsoever with any country beyond the Cape of Good Hope or the Straits of Magellan without a license from the Company. The charter, comprehensive as it was, was granted, and dated on the last day of the year 1600.

The title of the corporation was "The Governor and Company of Merchants of London trading into the East Indies." The corporation was empowered to make bye-laws, to export all kinds of goods free of duty, to export a certain quantity of foreign coin or bullion per annum, to inflict punishments and impose fines, and had other privileges conferred, which were likely to be of great pecuniary benefit. The charter was granted for fifteen years, but if found not of public advantage, it could be terminated at any time within the aforesaid period, on giving two years' notice.

The corporation, privileged as it was, started badly, many who had joined it for its privileges did not feel disposed to part with their money in fitting out expeditions, and on this account it was necessary to form subsidiary companies whose members possessed greater love of adventure than their colleagues in general, and for thirteen years the business was thus conducted. Large profits were frequently realised by these semi-private adventurers, and the Company was then moved to work on a larger and more comprehensive basis. But the desire to obtain special advantages was so great, that some of those members of the parent corporation who had formed subsidiary companies were opposed to a renewal of the charter, and thus for many years there were several companies or corporations possessed of special privileges, and which were constantly being harassed by private adventurers.

The ultimate settlement was brought about by a consolidation of the different interests associated with all the companies, and by the procuration of a consolidated charter to a corporation called "The United Company of Merchants of England trading to the East Indies" by the judicious and politic advance to the Government of £1,200,000 without interest. Modifications were afterwards made in the Company's constitution, and especially for placing it under more immediate Government control. But the Company was invested with great powers, and even in 1814, when privileges were granted to private traders, they were compelled to send their goods to India in vessels belonging to the Company, and the same system was compulsory on the part of the Indian merchant who wished to send goods to England.

Much more might be said on the interesting subject of the East India Company, its formation, constitution, and privileges, but it is our present purpose only to connect its operations with the importation and production of tea, and it was necessary to say as much as has been said for the purpose of establishing this connection.

From what has been stated, it is evident that, the supply of tea being till a comparatively recent date in the hands of the East India Company, it was practically a monopoly. Smuggling from the Continent prevailed to a certain extent, but this was considerably modified by the reduction of the duty, and would have been brought within much narrower limits if the absence of competition had not caused the price of tea to be much higher here than it was at Amsterdam, Hamburg, and other towns having an open trade with the East.

The effects of the monopoly were apparent in many directions. There was no keen competition on the part of the buyers for the Company, no inducement was offered by a large semi-irresponsible Company to direct enterprise into other than the ordinary markets, while the self-interest of private adventure led men to encourage competition, and to buy in that market where the best quality could be procured at the lowest price. This self-interest was apparent in the difference in price quoted for the same description of tea on the London and foreign markets.

A company having such special privileges granted them by the Government had certain heavy responsibilities imposed which fettered trade, and thus prevented the agents of the Company from giving the best of terms to the public. Some of these restrictions will have to be referred to later on, but it may be here sufficient to state that statisticians have estimated that in the latter years of the monopoly the consumer of tea had to pay very nearly £2,000,000 sterling a year on the quantity cleared for consumption more than if the same quantity and qualities of tea had been bought in the open markets of the Continent.

Whenever legislative changes were made affecting the tea duties, they were frequently coupled with specific regulations for controlling the supply of tea by the East India Company. Thus when the duty on tea was reduced in 1745, the Government enacted, in 18 Geo. II. c. 26, that as the reduction of duty was intended to increase the consumption, and that as the demand would probably be greater than the supply, the East India Company should have power to import into Great Britain from the continent of Europe any quantity of tea that might be necessary, subject to the several duties, and to the same rules and directions as were given with respect to tea imported by them from the East Indies. The Company had, however, to give notice to the "Commissioners of the Treasury of the intended quantity, with the name of the ship and master in which it is to be laden, and taking a license . . . . for landing and importing thereof."

The Government had, however, a suspicion that the altered state of the market through the reduction of duties might place the Company in such a position that it might either refuse or be unable to supply the increased quantity of tea that would be required, and they therefore took power to themselves to "grant licenses to any other persons, bodies, Politick or Corporate, to import tea from any parts of Europe in like Manner, and subject to such Duties, and under such Limitations, on such Notices, and with such Licenses as are herein before prescribed with Respect to Tea imported from any parts of Europe by the East India Company."

The Company, however, fulfilled its obligations to the satisfaction of the Government, and no licenses to other persons were issued.

When a further modification of duties was made in 1784, the Government again showed their desire to benefit the consumer by taking certain powers to themselves, and it was set forth in 24 Geo. III., cap. 38, s. 5 :—

"And whereas it is just and reasonable that the said United Company should, in Consideration of the great Benefit which may result to their Commerce from the Reduction of Duties hereby made, contribute their utmost endeavours for securing to the Publick the full Benefit which will arise from an immediate and permanent Reduction of Prices; be it further enacted by the Authority aforsesaid, That the said United Company shall, as soon as may be after the passing of this Act, put up and expose to publick Sale, at the least, Five Millions of Pounds Weight of Tea; and shall in like Manner, at some other time before the Thirty-first Day of December, one thousand seven hundred and eighty-four, make another Sale, at which they shall in the like Manner put up at the least two Millions five hundred thousand pounds Weight of Tea; and shall thenceforward continue to make at the least Four Sales in every year, and as near as conveniently may be at equal Distances of Time, and shall put up at such Sales such Quantities of Tea as shall be judged sufficient to supply the Demand, and that at each and every such Sale the Tea to be put up shall be sold without Reserve to the highest Bidder, provided an Advance of One Penny per Pound shall be bid upon Prices at which the same shall be put up; and that at the Four first Sales which shall be made after the passing of this Act, the Prices at which the said Tea shall be put up and exposed to Sale shall not exceed the following Rates, *videlicet*:—For Bohea Tea, One Shilling and Sevenpence per Pound; for Congo Tea, One Shilling and Fivepence per Pound; for Souchong Tea, Three Shillings and Threepence per Pound; for Hyson Tea, Four Shillings and Elevenpence per Pound; and that it shall not be, at any Time hereafter, lawful for the said United Company to put up their Tea for Sale at any Prices which shall, upon the Whole of the Tea so put up at any one Sale, exceed the Prime Cost thereof with the Freight and Charges of Importation, together with lawful Interest from the Time of the Arrival of such Tea in Great Britain, and the common Premium of Insurance, as a Compensation for the Sea Risk incurred thereon."

The United Company was compelled to provide against the demand of an increased consumption by providing a stock in warehouse equal to at least one year's consumption as determined by the sales of the last preceding year; and in addition to all this, the Treasury had the power to examine all books and documents for the purpose of verifying the *bona fides* of the Company with regard to quantities, the prices for auction purposes, and for other specified particulars.

Special provisions were made for relieving dealers in tea of their stocks which had paid the higher duty, and due consideration was given to the requirements of the trade for obtaining the relief from duty to which they were entitled.

It is difficult to see what connection there was at the time of the reduction of duty between tea and the windows of dwellings; but the Government of the day increased the window tax to recoup the Exchequer for the loss likely to occur from a reduction of the tea duty, and it was enacted that on every house rated by Act 6 Geo. III. at 3s. an additional 3s. should be charged. For every dwelling-house rated for 7 windows there should be an increase of 6s.; 8, 8s.; 9, 10s. 6d.; 10, 13s.; 11, 15s. 6d.; 12, 18s.; 13, 21s.; 14, 25s.; 15, 30s., and 5s. additional for each window up to 25; then 10s. additional for every 5 windows up to 99; then 20s. for every 10 windows up to 179; and for 180 and upwards, £20.

It was laid down in the Act how the money thus raised was to be brought to account, and how the surplus, if any, was to be used for the purposes of Government.

The effect of lowering the duty naturally was that much larger quantities of tea were consumed, the result to the Revenue being that instead of an expected deficit of upwards of £600,000, the actual decrease was only from £700,000 to £340,000. This Commutation Act of Pitt has been considered a very praiseworthy and satisfactory performance, but the increased amount obtained from the tea duties and window tax combined was easily spent, and soon the screw was put on to increase the duty. In 1795 the duty was raised to 20 per cent., *ad valorem*, and after several further increases the duty was fixed in 1819 at 100 per cent. on all teas which realised at the Company's sales above 2s. a pound.

The effect of the monopoly of the East India Company was observable to the distributor and consumer. The Government restrictions imposed on the Company tended to increase prices, and the absence of competition enabled the Company to extort at their sales such high prices that tea could only reach the consumer at a cost which, except to the well-to-do, was almost prohibitive. The regulations of the Government had also a disastrous effect on the quality of the tea. For instance, the tea sold by the Company could not reach the consumer till it had been packed over 12 months, and, in fact, evidence was adduced that the tea was kept on an average 17 months before it was put into consumption. Tea so kept must naturally deteriorate largely in quality, and for an illustration we need only refer to the reduction of the prices of old season's tea as soon as the new comes on the market. It is only just to state that nearly all the Chinese teas are so well cured that they deteriorate least by keeping; but much of the Indian and Assam tea falls off wonderfully through keeping, till at the present time this fact is fully recognised by the trade, and the stock of these teas is kept as small as possible.

The monopoly of the East India Company enabled them to control the supply of tea, and it was always to their interest to put a short supply on the market to obtain better prices for that sold.

Private enterprise, if allowed, would soon have remedied such a state of things, and healthy competition would have killed the monopoly. But this was not allowed, and consequently prices were charged which had not only to cover the large profit put on the tea, but also to make amends for reckless expenditure in China and at home through the absence of commercial rivalry. Such a system could not last on account of its injustice to the consumer and the special privileges it enjoyed. Gibbon describes monopolists thus:—"The spirit of monopolists is narrow, lazy, and oppressive. Their work is more costly and less productive than that of independent artists; and the new improvements, so eagerly grasped by the competition of freedom, are admitted with slow and sullen reluctance in those proud corporations above the fear of a rival and below the confession of an error."

Such a corporation had to work through servants; individuality was to a great extent lost, and the enterprise, courage, fertility of resource, and skill which are necessary to make the character of an able and successful merchant were clouded, if not destroyed, by the red tape system of a corporation mostly governed by men of small commercial experience of any kind, and of quite as little knowledge of the requirements of their Company; men apt to resent any overture of a novel kind, however good, desiring only to pursue the high and dry methods of business which had been in vogue for centuries, but which were already quite out of date when applied to modern commerce.

Extravagance in administration, and consequent high prices of goods sold under this monopoly, led some gentlemen to look into the business of the Company, with a view of seeing whether the extravagance of working did not eat up the profits on the sales, or rather what was charged over and above the continental importers' prices. This inquiry brought out the following curious result:—

	£
Profits realised by the Company in three years ending 1828	2,542,569
Average	847,523
Excess of price received for the Company's teas over the price of such teas sold at New York and Hamburg	1,500,000

There was, therefore, an absolute loss, through the monopoly, of £652,477 a year, in addition to the odium attached to a system which diminished trade, choked competition, and increased the cost of the necessaries of life.

When the time came for the renewal of the charter these facts were not forgotten, and the Act 3 and 4, William IV., c. 85, abolished the monopoly, made it lawful for all persons to import tea, and thus gave power to those who wished to open up a trade with China.

From the Table given below it will be seen that the monopoly of the East India Company enabled the Government to charge different rates of duty on the several classes of tea. Thus the duty was, on—

	Per lb.
Bohea	1s. 6d.
Congou, Twankay, Hyson Skin, Orange Pekoe, and Campoi	2s. 2d.
All other sorts	3s. 0d.

With the removal of the monopoly the classification was, as a matter of course, broken, and for fiscal purposes eventually abolished. The importer would at all times be anxious to obtain the highest price for his tea, but naturally would wish to pay the lowest duty. Evasions and wrong descriptions led the Government to adopt one rate, and from July 1st, 1836, the duty on tea was fixed at 2s. 1d. a lb.

An *ad valorem* duty, if it could be justly levied, would certainly be the most equitable, and the principle in the abstract has always been favourably entertained. But such a duty in its incidence has always broken down, and there are not wanting numerous illustrations from practical experience to prove to demonstration that the cunning of the manufacturer or importer will in time be more than a match for the most acute of revenue officials, and that in such matters legislation is practically powerless. We have seen in our first lecture on sugar what artistic evasions there were of the system of classification for duty, and how easy it was for slave-grown sugar to be bartered for goods of British manufacture, or paid for in sterling coin in defiance of the express Acts of the Legislature, and in the article of tea open competition speedily abolished *ad valorem* duties.

With the rapid growth of tea as an article of domestic consumption there has always been a desire to tax the lower qualities consumed by the poor less than the better descriptions consumed by the rich, but no practical method has yet been devised for carrying out this object. It was thought that the alkaloid (theine) present in tea might be used as the factor for so doing, but unfortunately the proportion of this alkaloid in tea bears no relation to its commercial value, and consequently the investigation was barren of results.

The quantity of low-priced tea consumed is now much larger in proportion to the total quantity cleared for home consumption than it used to be. The late duty of 6d. per lb. was therefore on this account more onerous than formerly, and we may expect that when a Chancellor of the Exchequer has in any year a large surplus, we shall see the tea duties further reduced, if not abolished altogether. Such a step would be most popular, and as the agitation in favour of a free breakfast table has not died out, but is only slumbering till the money and the man can be found for effecting this

TABLE XXVIII.—TEA DUTIES.

YEAR.	RATE OF DUTY.			
1660–1869	8d. per gallon made and sold.			
1689	5s. per lb. (Excise).			
1745-1745	4s. ,, ,, and 14 per cent. ad valorem (Customs).			
1745	1s. per lb. and 25 per cent. ad valorem.			
1748	,, 30 ,, ,,			
1759-1784	65-120 ,, ,,			
1784-8	12½ ,, ,,			
	Great Britain.		Ireland.	
			Black.	Green.
1789-90	12½ per cent. ad valorem.		4d. per lb.	6d. per lb.
1791-4	12½ ,, ,,		4¼d. ,,	6½d. ,,
1795-6	20 ,, ,,		4¼d. ,,	6½d. ,,
	At or above 2s. 6d. per lb.	Under 2s. 6d. per lb.		
	Per cent. £ s. d.	Per cent. £ s. d.		
1797	30 0 0	20 0 0	4¼d. ,,	6½d. ,,
1798	35 0 0	20 0 0	4¼d. ,,	6½d. ,,
1799	35 0 0	20 0 0	5½d. ,,	7d. ,,
1800	40 0 0	20 0 0	5½d. ,,	7d. ,,
			All sorts.	
			At or above 2s. 6d. per lb.	Under 2s. 6d. per lb.
			Per cent. £ s. d.	Per cent. £ s. d.
1801	50 0 0	20 0 0	35 0 0	20 0 0
1802	50 0 0	20 0 0	38 10 0	23 10 0
1803	95 0 0	65 0 0	38 10 0	23 10 0
1804	95 0 0	65 0 0	84 14 0	51 14 0
1805	95 2 6	65 2 6	84 14 0	51 14 0
1806	£96 per cent.		84 14 0	71 14 0
1807-9	,, ,,		84 14 0	71 14 0
1810-13	,, ,,		£93 per cent.	
1814-18	£96 per cent. ad valorem.			
	Above 2s. per lb.		At or under 2s. per lb.	
1819-33	£100 per cent.		£96 per cent.	
1834 (April 22)	Cessation of ad valorem duties.			
1834-5	Bohea, 1s. 6d. per lb.; Congou, Twankay, Hyson Skin, Orange Pekoe, and Campoi, 2s. 2d.; all other sorts, 3s.			
1836-9	All sorts, 2s. 1d. per lb.			
1840-50	,, 2s. 1d. ,, with 5 per cent.			
1851-3	,, 2s. ,, ,, ,,			
1854	,, 1s. 10d. ,,			
1855	,, 1s. 6d. ,,			
1856	,, 1s. 9d. ,,			
1857-62	,, 1s. 5d. ,,			
1863-4	,, 1s. ,,			
1865-89	,, 6d. ,,			
1890 (May 1)	,, 4d. ,,			

object, the measure, on account of its immense popularity, will not be delayed beyond the bounds of prudence, and before long the tea, coffee, and cocoa duties may be abolished.

Mr. Goschen has taken a step in this direction by reducing the tea duty from 6d. to 4d. per lb. On a future occasion he may go further by making another sensible reduction. The popularity of tea as a beverage proves the wisdom and sound policy of such a proceeding, and in the cause of temperance it would be prudent to lower the rate, the increased consumption going far to recoup the Revenue from anticipated loss.

A copy of an East India Company's tea warrant is here introduced, which may be of interest, especially as showing the discount then allowed by the Company. The different rates of duty from the first imposition down to the recent reduction are also given in p. 1024, in tabular form:—

Copy of Tea Warrant (now in the possession of Messrs. Holborn, of Mincing-lane).

No. 644.

You are desired to deliver to
Mr. Joseph Lewin
the following goods: viz.,
No. 5.—1 Chest Bohea Tea — 301 lbs. @ 15/-
= £225 15 0.

Sold him by the United East India Company in Sept., 1720, he having paid for the same £101 1 7 on account, for which he hath a receipt of this No. and date—

Discount £14 13 5.
Balance £110 0 0.

London, 20 March, 1720.
Joseph Micklethwaite.

The Tea Plant.

The term "tea" is properly restricted to the numerous varieties derived from cultivation of the two species of *Thea—Thea chinensis* and *Thea assamica*. Hybrids of various degrees between these two form a great part of the plants usually grown. In the tea-garden the plant is kept down to 3 to 6 feet in height; in a state of nature it reaches 30 to 40 feet, with a stem 1 foot in diameter. The seed, which is enclosed in a hard, round shell, ripens about one year after the flower has faded. Planting is done either direct from the seed itself, or from nurseries where the young plants can be watched carefully and tended until they are strong enough to take their places in the plantation. When plants are to be raised direct from seed, the usual method is as follows;—Holes are dug, left for about two weeks, and then filled with surface soil. Two or three seeds are sown, six inches apart, in each hole, and about one inch deep, gently pushed down. In each hole the best plant is left, the others being transferred to vacancies. Tea grows on almost all soils, but one that is light, friable, and rich is necessary for complete success. Oak-bearing land seems to unite all essentials, and is much esteemed. Flat land is fair, but undoubtedly the best situation is the lower part of a slope near a good water supply. As regards the number of plants to the acre, close planting is recommended, viz., about 4 feet apart, equivalent to 2,722 shrubs per acre. On steep slopes the Chinese variety may be planted closer—2 feet by 3½ feet, or 6,223 per acre. A good deal of care must be devoted to pruning, with the object of keeping the shrub well spread, and at a convenient height for picking. A judicious system of manuring nearly doubles the yield of tea, improves its flavour, and increases its strength. An excellent manure is bush prunings, weeds, and general rubbish. Animal manures require care in using.

A tea plant is picked as the successive "flushes" occur. A "flush" of the plant is the throwing out of new shoots and leaves, the latter forming the tea of commerce. The average flushing period is seven to nine months, and the intervals vary from seven to fourteen days. The number of flushes ranges from eighteen (where no manure is used) to twenty-five (in good soil).

To a certain extent, the harder a tea plant is picked, the more it becomes stimulated to reproduce new shoots in place of those lost. When the season is over, the tea bush is from 3½ to 4 feet in height and about 5 feet in diameter; by pruning down, its height is reduced to 2 feet and its diameter to 3 feet. In this state it remains during hybernation. In the spring the buds at the base of the leaves develop into shoots, the buds of which in turn develop themselves in the same way. The first shoot from the branch becomes the nucleus of subsequent flushes on that part of the bush, and is therefore carefully preserved. It is not, however, left to grow *ad libitum*, as its faculty of throwing out new shoots is greatly enhanced by nipping off the leaves in such a way as to avoid injuring the young buds at their bases. The lines in the diagram on the wall indicate the points at which this operation should be performed.

The youngest leaves give the best tea, and the order of merit is as follows :—

a gives Flowery Pekoe; *b*, Orange Pekoe, *c*, Pekoe. "Poco" means the white hair or down of the under leaves.

d gives First Souchong; *e*, Second Souchong. Souchong means "small plant."

f gives Congou. Congou means "labour," expressing care required in the preparation.

a, *b*, *c* mixed give Pekoe; *a*, *b*, *c*, *d*, *e* give Pekoe Souchong.

Hyson may be called the parallel of Souchong in black leaf descriptions; the word means "before rain," or "flourishing spring." "Hyson skin" is the refuse of teas; the native term for it is "tea skins;" the coarser refuse is called in the vernacular "tea bones." These various classes are finally sifted and sorted.

In the process of manufacture the freshly-gathered leaves have first to undergo "withering," which is best done by spreading them in the sun, a superior method to any artificial one. When properly and perfectly performed, withering renders them inelastic; the stalks bend without breaking, while there is no crackling on compression. The withered leaves are next rolled by a line of men on each side of a table, who pass them one by one from one end to the other. The roll is ready to make into ball when it is soft and "mashy," and gives out juice freely. The juice is mopped up into the roll again and again in its passage up the table, and is finally left in the ball when made. Coarse leaves are carefully eliminated from the rolling process, in which many machines are now in use. The balls stand until fermented; practice alone can afford reliable information as to the time this should take. It is stopped by breaking up the ball and spreading the loose leaf thinly on mats in the sun. When blackish it is collected and re-spread so that the whole may be equally affected. As soon as possible after breaking up the balls it is necessary to drive off the moisture, the least delay before "firing" being injurious. McMeekin's chest of firing drawers, now much in use, consists of drawers one above the other, the bottom of each tray being made of fine wire gauze. The heat is thus utilised through the whole series. In many cases hot air is used in place of the old charcoal fires.

When green tea is required, the fresh leaf is brought in twice daily; that which comes in at 1 p.m. is partly made the same day, that brought in at evening is spread six inches thick till next morning. When necessary the leaf is dried, and when dry is put into pans over fires till heated to 160° Fahr., and vigorously stirred for about seven minutes. It is next rolled and dried in the sun, while the latter operation is proceeding it is rolled three times more, then it is replaced in the pans at the same temperature (160° Fahr.), and afterwards stuffed into bags and beaten heavily. Remaining in the bags through the night, the tea is next morning worked again at a temperature gradually falling from 160° to 120° Fahr.; the green colour is retained in this way. The leaves of the Chinese plant make the best green tea, while hybrids are best for black.

The next important item in the manufacture is sifting and sorting. The sieves used are round, made of either brass wire or cane, and have wooden sides 3½ inches high. Before commencing to sift red leaf is carefully picked out.

The form known as brick-tea is of three kinds; the first and largest is much used in West and North-West Siberia, and measures one foot long by seven inches wide, weighing about 3½ lbs.. These blocks are made in wooden moulds, and are pressed and dried by hand labour. A basket of 36 cakes costs about 28s. The next kind measures 8¼ inches by 5¼ inches, and weighs 1½ lbs. It is of a superior quality to the first-mentioned, a basket of 80 to 90 costing about 34s. It goes mostly to West and North-West Siberia. The third kind is made from black tea dust, now generally pressed together by steam machinery. The cakes are 6 inches by 8½ inches, and weigh about 2¼ lbs. They are packed in baskets of 64, costing 33s.

Tea and Tea-making.

In considering tea, as at present used as a beverage, from a physiological standpoint, it may be observed that there are three of its constituents which call for special observation, viz., the aromatic volatile oil, the alkaloid, and the tannin.

The volatile oil is the chief factor in imparting to tea its peculiar fragrance and characteristic taste, but the physiological advantages of these flavouring materials are somewhat counterbalanced by the effects of the tannin.

The alkaloid (theine or caffeine) is that principle to which tea chiefly owes its stimulating and invigorating properties. Its action is almost entirely limited to the nervous and circulatory systems. The brain is at first stimulated, and thereby follow clearness of intellect, removal of languor, and supervention of sleeplessness. In very large quantities theine produces a species of narcotism, and when administered to the lower animals has been found to cause convulsions similar in kind to those induced by strychnine poisoning. In man muscular irritability is increased, but this is quite subsidiary to the effects upon the brain. After small quantities there is no well-marked stage of reaction, but long-continued indulgence in large quantities of strong tea is generally followed by very distressing symptoms of nervous irritability and depression. In some forms of megrim, or sick headache, the alkaloid will occasionally afford very great relief. The heart and respiration are temporarily stimulated, hence the refreshing effect of tea in ordinary conditions of fatigue. Habitual use greatly diminishes the stimulant without correspondingly diminishing the subsequent depressing effect of the alkaloid.

The tannin is the principle to which tea owes its bitter and astringent properties, and of which it is desirable to extract as little as possible while "infusing the tea," because tannin exercises a generally undesirable effect on the digestive system. In the mouth its astringent action and depressing effect on salivary secretion may in many cases more than counterbalance the stimulant effect of the volatile oil. It is in the stomach, however, that tannin exerts its most injurious influence, first by impairing the action of the gastric fluids, secondly by a combination with certain of the nitrogenous principles of food analogous to that which occurs in the manufacture of leather, and, thirdly, it diminishes the circulation in the mucous membrane, and thus interferes with its normal activity of secretion. The astringent effect of tannin is continued in the intestines.

We conclude, therefore, that tea quickly and freshly prepared, and taken in moderation, is a very valuable, agreeable, and stimulating beverage, but that large potations of badly prepared strong tea exert a very depressing action on the heart and nervous system, and are a fruitful source of dyspepsia and constipation.

Females who usually lead sedentary lives are the great consumers of tea, and very frequently, where many work together, the tea-pot is generally found on the hob, for supplying a cup whenever needed. Tea so made is stewed rather than infused, and, as a rule, whenever a fresh supply is wanted, a small quantity of fresh tea is put into the pot to the exhausted or partially exhausted leaves, and this is repeated during the day as often as occasion requires. The consequence is that the ill-effects arising from a sedentary life are heightened and aggravated by drinking large quantities of tea containing a maximum of tannin, and the results are well known to be very prejudicial to the health of our female population.

The Chinese, who may justly claim to be the inventors of tea-drinking, do not use tea-pots as a rule, but simply infuse the tea with water much below the boiling point in the cups from which it is drunk from the leaves without milk or sugar. It is true that the tea for home use is not cured in the same way as tea exported to foreign markets, but the beverage is so made as to contain a maximum of flavouring matter with a minimum of tannin extractive, and is not unpleasant to those unaccustomed to drink tea in such a novel fashion.

But the important subject of tea-making claims consideration not exactly on account of its difficulty—nothing could well be simpler—but because many persons habitually lose the fine flavour and aroma, and drink, day after day, a liquid which is neither nice nor refreshing. There is an overwhelming opinion, backed by the long experience of the great tea houses, in favour of the water being used immediately the boiling point is reached—the time of infusion being limited to five or six minutes. Sometimes a little boiling water is added to "draw" the tea, sometimes the tea-pot is warmed; these are more or less matters of detail which do not much affect the result. The important point is not to boil the tea, either by stewing the leaves or, as sometimes advocated, by re-heating the infusion. The best and fullest yields are obtained in five or six minutes, after that it would seem that the bouquet and flavour are greatly deteriorated. Tea should not be boiled under any circumstances; the leaves are practically exhausted in less than fifteen minutes, and to boil the tea is to deprive it of its most grateful and volatile characteristics.

Illustrations of badly-made tea are unfortunately not difficult to find, for notably at railway stations and coffee-taverns, the large tea-urn with a lamp underneath is a part of the stock in trade, and the tea from such a source is not refreshing, its flavour revealing at once that it has been more or less stewed, and even the addition of sugar and milk does not conceal its defective qualities. Such tea being always ready for consumption is no doubt a convenience, and its cost is much less to the maker than tea freshly made for each customer, but the public taste has in this respect become more refined, and those individuals or companies who, at the sacrifice of some of their profit, have supplied customers with tea made at the time of ordering, in a separate pot, have commanded general confidence, and been favoured with a very large share of public custom.

TABLE XXIX.—Composition of Tea.

	Congou.	Young Hyson.
Moisture	8·20	5·96
Theine	3·24	2·33
Albumin (insoluble)	17 20	16·83
,, (soluble)	·70	·80
Extractive by alcohol, containing nitrogenous matter	6·79	7·05
Dextrin or gum	—	·50
Pectin and pectic acid	2·60	3·22
Tannin	16·40	27·14
Chlorophyll and resin	4·60	4·20
Cellulose	34·00	25·90
Ash	6·27	6 07
	100·00	100·00

TABLE XXX.—China and India Tea.

Kind.	Specific Gravity of Standard Infusion.	Per-cent. Moisture.	Per-centage of Ash.			
			Soluble in		Insoluble in Acid.	Total.
			Water.	Dilute Acid.		
China—						
Hyson (young)	1013 67	6·90	3·82	2.52	1·13	7·47
Hyson	1012·35	7·25	3·82	2·37	·36	6·55
Congou	1009·88	9·22	3·55	2·12	·28	5·95
Pekoe (orange)	1013·31	7·70	3·99	2·27	·46	6 72
Souchong	1011·44	9 36	3·61	1·95	·29	5·85
Scented Caper	1013 50	6·63	3·47	2·23	·93	6·63
India—						
Hyson	1013·80	7·36	3·44	2·25	·43	6·12
Congou	1012·68	9·68	3·53	1·87	·26	5·66
Pekoe (orange)	1014·32	7·84	3·45	2·83	1·34	7·62
Souchong	1013·59	8·28	3·24	2·42	·62	6·28

The wholesale tea dealer who, as before observed, is so particular in making tea in the best manner for guiding his judgment as a buyer, has been equally anxious to take into account the effects of soft and hard waters upon tea, to enable him to sell to his customers in different towns tea best suited to the local water supply. It is notorious that tea which is suited to soft water infusions will not yield the same result with hard water. As a consequence, the intelligent wholesale dealer of to-day finds it worth his while to make tea analyses with the waters of different towns and districts which his travellers cover, and in this way he is able to assist the local distributor in his selection of tea, and give him sound and practical advice on the subject.

Undoubtedly the character of the water influences the amount of albuminoids extracted, a point well understood in the brewing trade, and as in the case of the brewer, the tea merchant must be able to sell single or blended teas which will yield with the local water supply the maximum of quality at the lowest price.

The results in Table XXIX. were obtained from the analysis of a Congou tea at 2s. 10d., and a young Hyson at 3s. per pound. They were selected as being fair representatives of black and green tea.

Tea Analysis.

Complete analyses have been attempted, but with somewhat discordant results; for commercial purposes only the more important constituents are determined.

Oil.—The tea is distilled with water, the distillate filtered, saturated with chloride of calcium, extracted with ether. Evaporation in a tarred beaker gives the weight of the oil.

Theine.—In addition to the method recently given by Dr. Paul, there are two others of importance. The better may be thus described. A small quantity of dry powdered tea is mixed with calcined magnesia, boiled with strong alcohol and filtered. The residue is again boiled with alcohol, filtered, and then similarly boiled three times with water. From the alcoholic filtrates the spirit is removed by distillation, and any colouring matter by addition of water. The aqueous filtrates are now all united and brought to dryness, a little magnesia being added. Extracted with hot benzol, theine, crystalline and colourless, may be obtained by evaporation.

Below is a Table showing the per-centage of theine in a number of different teas.

Tannin.—None of the methods are wholly satisfactory. Perhaps the best is a modification of Löwenthal's, which depends on the deoxidising action of tannin on potassic permanganate.

The albumen, pectin and pectic acid, dextrin, cellulose, chlorophyll, and resin, call for no special remark.

The ash may be conveniently estimated by burning at a low temperature, and not allowing the tea whilst being carbonised to burst into flame. This precaution practically obviates any loss of chlorides, especially as the ash of genuine tea is always alkaline, the chlorides being thus comparatively stable. The alkalinity of the ash is an important point in tea analysis, and the determination of the alkalinity should always be made. The quantity of nitrogen present in tea was found by early investigators very much higher than was represented by the theine extracted. This difference has, however, been modified through the discovery of more perfect methods for extracting the theine.

			Per cent. of theine.
Mulder	found in	Green tea	0·43
,,	,,	Black tea	0·46
Graham	,,	Congou	2·09
Stenhouse	,,	Himalaya black ..	2·05
Peligot	,,	Hyson	2·2 to 3·4
,,	,,	Gunpowder	2·2 to 4·1

And in the Inland Revenue Laboratory, when determining whether theine could be made the basis for charging the Customs duty on importation, the following per-centages were obtained :—

	Per lb. s.	d.		Per cent. of theine.
Bohea	1	7	....	3·31
Congou..............	2	6	....	2·93
Young Hyson	3	2	....	4·29
Gunpowder, low	2	6	....	3·18
,, good	5	0	....	4·98
Assam, low	2	8	....	3·03
,, good	4	6	....	4·83

Dr. Paul has lately made a large series of experiments on teas (chiefly Pekoe) obtained from different plantations in Ceylon and India, and recently published his results. They are interesting as dealing with tea which is steadily superseding China, and are therefore given in the following Table :—

TABLE XXXI.—Tea (*Theine*).

	Elevation at which grown.	Moisture per cent.	Theine per cent. Original Tea.	Theine per cent. Dry Tea.
CEYLON.	Feet.			
Penhros.........................	2,500	6·8	4·56	4·89
F. L. C.	—	6·0	4·55	4 85
Nahalma	300	5·6	4·54	4·80
Hairs from leaves...........	—	6·6	2·40	2·57
Hardenhuish Pekoe.........	3,500	3·8	4·03	4·24
Woodstock Pekoe Souchong.....................	4,200	3·6	3·44	3·57
Radella Broken Pekoe ...	4,800	4 6	4·10	4·30
Morton Pekoe	400	4·2	3·98	4·15
Penhros Broken Pekoe ...	2,500	6·4	4·64	4·96
Strathellie Orange Pekoe	2,000	5·4	4·10	4·33
Nahalma Orange Pekoe...	300	5·4	4·06	4·29
Venture Orange Pekoe ...	4,300	5·4	3·74	3·95
St. Leys Pekoe Dust	4,600	5·6	3·46	3·66
Venture Pekoe Souchong	4,300	4·8	3·40	3·57
Venture Broken Orange Pekoe	4,300	6 6	3·98	4·26
Calsay Pekoe Souchong...	5,000	6·2	3·22	3·43
Venture Pekoe	4,300	5·6	3·48	3·68
St. Clair Orange Pekoe...	4,200	4·6	3·90	4·09
INDIA.				
Pekoe tips, picked out......	—	7·56	4·27	4·62
Broken Pekoe.................	—	7·00	4·48	4·81
Pekoe	—	6·40	4·16	4·44
Orange Pekoe	—	4·80	4·66	4·89
Pekoe	—	5·60	4·48	4·74
Broken Pekoe	—	4·80	3·76	3·95
Pekoe	—	5·40	3·66	3·86
"Weak" tea	—	6·80	4·06	4·35
"Strong" tea	—	5·80	4·18	4·43
Mixture	—	6·00	3·64	3·87

The results given ranging from 3·22 to 4·66 per cent. of theine in tea as imported, are considerably higher than have been obtained by experimenters using more imperfect methods for the separation of the alkaloid, and at the same time it is obvious, from the results obtained, that the theine present could not be used as a factor for fixing the commercial value of tea, although the physiological value of the tea itself is mainly dependent on the quantity of the alkaloid present.

The professional tea taster, when judging the value of tea, is mostly guided by the colour, uniformity, and age of the leaf, and the bouquet, flavour, and pungency of the infusion, which characteristics are largely due to the quantity and quality of the volatile oil the tea naturally contains.

Chemical analysis has never been used as a factor for determining the commercial value of tea, and apart from the chemical analysis, a little consideration of the subject shows there are special reasons why it never can be so used. Broken leaf will produce as much theine as the whole leaves of the same description of tea, but commercially such imperfect leaves always command a lower price, as the size and appearance of the leaves are important elements in fixing their trade value. As before stated, chemical experiments have been carefully made with the object of seeing whether there is any relation between the chemical and commercial value of tea, but the results obtained were, as might have been expected, anomalous, and gave no encouragement for further investigatiou in the same direction. Tea hairs, sometimes imported as flower of tea, contain theine, but not in such large proportion as the leaf from which they have been detached. It has been stated that the smaller quantity present is due to the fact that the alkaloid does not exist in the hairs, but in the portion of leaf attached thereto, but this statement is not correct, as the hairs themselves contain theine.

The quantity of theine present in tea as drunk is about two grains in eight fluid ounces, if the tea is of the strength of the infusion made by commercial tea tasters, viz., the weight of a sixpence (43½ grains) in 3½ fluid ounces of water, put on the tea at a boiling temperature. Twenty per cent. of the total extract is thus obtained, and may be safely computed to contain 50 per cent. of the total theine.

TEA IN INDIA AND CEYLON.

Tea would appear to have been known in India for more than a hundred years. In 1780, a resident in Calcutta, named Colonel Kyd, had the tea plant growing in his garden, and other instances are also on record of its existence in India, where the question of its acclimatisation began to be discussed. Warren Hastings, then Governor-General of India, writing in 1780 to Mr. G. Boyle, "sends him some seeds of Hyson tea to aid his benevolent plan of introducing the luxuries and excellencies of our world into that of Bhootan." Colonel Kyd also, writing in 1782 to Sir Joseph Banks, says "the tea plants received from Canton have thriven well, although in most unsuitable soil and climate; the supercargoes are to be blamed for having sent only the worst sort (which are never prepared for the European market), and refusing to procure native cultivation at the request of the Bengal Government." Later on, in 1788, Sir J. Banks, on behalf of the East India Company, submitted to the authorities a statement containing information and guidance on the subject of tea and several other agricultural products, in the cultivation of which much improvement was desirable. On December 27, 1788, a communication was sent from London to Bengal, in which the authorities there were invited to give their earnest attention to a subject "both political and commercial." The Bengal Government consulted Colonel Kyd, and that gentleman found himself in thorough agreement with Sir Joseph Banks. The Government, however, while noting Colonel Kyd's views, seem to have refrained from adding any views or sentiments of their own. As the subject indicated a possible rival to the China tea trade (in which the East India Company had a monopoly), it is possible the matter was discouraged. The lull, too, in the question, after Colonel Kyd's death seemed to accentuate the reserve on the part of the East India Company, but a few years later the discovery of indigenous tea in Assam gave the subject new prominence. The Society of Arts also endeavoured to encourage the cultivation of tea wherever possible, for in 1825 they offered their gold medal "to the person who shall grow and prepare the greatest quantity of China tea, of good quality, not being less than 20 lbs. weight," in the East Indies and other British colonies. This prize, however, remained unclaimed for about twenty years, till in 1839 a Mr. C. A. Bruce, who was in command of a division of gunboats in the first Burmese war, and to whom—whether rightly or wrongly—the discovery of tea in Further India is attributed, was awarded the medal, "for discovering the indigenous tea tracts, and successfully cultivating and preparing tea in the British possessions in India." The credit of this discovery has been claimed, however, for one or two others—a native named Moneram Dewan, and a Captain Charlton, of the Bengal Army; the latter disputed Bruce's title on the ground that he himself had drawn attention to the existence of the tea plant in Assam in 1832—in fact, he received a medal from the Calcutta Agricultural Society for the discovery. The matter had then succeeded in engaging the attention of the authorities for, in 1834, a committee sat to inquire into the possibility of cultivating tea in India; and in the following year the Government first tried to establish a tea-garden at Lakhimpore, which, although in Government hands, failed, and the plants were taken to Jaipore. The garden established there was purchased in 1840 by the Assam Company, then only about a year old, and the first Indian tea company formed. Its early existence was not a great success for several reasons. Indian tea, as a novelty, had to fight its way up; India itself was too far off, as travelling was then; and the public were very little informed about Assam. It was ten years or more before tea-gardens became numerous. In 1853 tea was found growing in Cachar, and in 1856 in Sylhet; by 1864 Kumaon, Darjeeling, Chittagong, &c., were planted, and more recently, Chota Nagpore and Ceylon, about 1872.

Once attempted, the growth and manufacture of tea in India was soon a *fait accompli.* About 1839 the Council of the Society of Arts was asked to report on samples received through the East India Company. In this matter Messrs. Thompson and Twining, names still well known in the tea trade, kindly volunteered their opinion and experience, and the teas were pronounced of superior quality, the infusion being of a deep rich red, of pungent flavour, and resembling the Pekoe of China. The following year further samples were submitted to the Society, and elicited the following report:—"Indian tea possesses all the richness, strength, and flavour of the finest kinds imported from China. The preparation now excels every expectation that could have been formed of the improvement in so short a time, and India unquestionably possesses every requisite of soil and climate for producing teas of the finest quality." From this commencement the enterprise grew apace; too fast, in fact, for the eagerness of the public to invest caused estates to fetch many times their value, and this artificial inflation soon brought about the inevitable crisis. Huge profits and dividends had been made, not so much from tea manufactured as from seed sold, seed growing being comparatively easy, and necessitating less labour. Of course, temporary success led to extravagance, not to say fraud, company promoters having been known to sell land which had no existence.

The Indian tea industry is now, however, well established, and the number of acres devoted to it can be counted by thousands.

CEYLON TEA.

As stated, the coffee plantations in Ceylon were almost entirely destroyed by disease in 1868, and the planters, being driven to their wits' end for an alternative crop, grew cinchona—a plant included in the coffee family—and tea. The tea produced is one possessing some of the good qualities of both India and China teas, and as it can be used without blending, it has grown greatly in public favour, its consumption in the United Kingdom last year being upwards of 30,000,000 lbs. Its keeping qualities are not always satisfactory, and much of it deteriorates rapidly on exposure to the air. The following Table of imports will be interesting:—

TABLE XXXII.—IMPORTS FROM CEYLON.

	lbs.		lbs.
1873 ...	23	1881....	500,000
1874....	492	1882....	750,000
1875....	1,400	1883....	1,500,000
1876....	757	1884....	2,250,000
1877....	2,000	1885....	3,750,000
1878....	20,000	1886....	7,000,000
1879....	100,000	1887....	11,250,000
1880....	150,000	1888....	20,500,000

Last year 32,516,682 lbs. were exported from the island.

The foregoing brief *résumé* of the progress made in growing tea in India and Ceylon indicates the marvellous success which has attended this industry. Great as this success has been, the fact must not be overlooked that many Indian tea-gardens are even now worked at a loss, and that some of the successful ones are not doing what might be accomplished if quality as well as quantity were made a factor in the preparation of tea for the British and other markets. The planters deserve the greatest praise for what they have done, but in their competition with the Chinese tea growers, they have really been greatly protected by the action of the Chinese Government, who levy heavy duties on the tea exported. In the losing race, the Chinese Government may be tempted to remove this export duty, and if they do so in time, the Indian planter will have much greater difficulties to encounter in the future to ensure continued success. The Chinese are keenly alive to the loss of trade by present fiscal regulations and change of fashion, and as the Government is doing what it can to improve the quality of tea exported, the next step will probably be the substitution of other taxation for that now imposed on tea exported.

The following facts taken from the last report of the Commissioners of Chinese Customs at Canton will show that the condition of the tea industry has become a burning question, and in face of what may be done in the immediate future to relieve the tea grower and exporter, it would be prudent on the part of our growers to produce the better qualities of tea, and cure it so thoroughly as to remove the present complaint of its uncertain keeping qualities. Uniformity of quality is always a safe factor in trade competition, and up to the present time this fact has not had sufficient weight with the Indian tea grower.

The Canton Commissioners thus review the condition of the tea industry :—

"The inland transit dues in the Canton province amount to about 10 per cent. of the export value, and export duties to 19 per cent., making 29 per cent. in all; the total sum derived from the export duties alone being, in 1888, over £1,000,000. On the other hand, Indian teas are quite unburdened in these respects, and in view of this fact the feasibility of the removal of these duties by the Chinese Government has been much discussed. The Commissioners think even this heroic measure insufficient to avert the continued displacement of Chinese by Indian tea. Bulk for bulk, the latter is the stronger, its distinctive flavour is well liked, and scientific methods of production and distribution, unknown in China, are in common use in India. In short, the future of the Chinese trade is very gloomy, so much so, indeed, that if the most energetic measures of reform, embracing even the permission to foreigners to establish themselves as in India, be not soon adopted, the practical extinction of the Chinese tea trade is considered to be only a matter of time."

TABLE XXXIII.—OF EACH 100 LBS. IMPORTED.

	China contributed	India contributed	Ceylon contributed	Other countries contributed
1864.........	92·55	2·84	—	4·61
1865.........	93·00	2·50	—	4·50
1866.........	93·74	3·88	—	2·38
1867.........	91·81	6·07	—	2·12
1868.........	91·77	5·89	—	2·34
1869........	90·85	8·07	—	1·08
1870.........	89·06	9·17	—	1·77
1871........	88·25	8·91	—	1·84
1872.........	86 80	8·89	—	4·31
1873.........	83·81	11·28	—	4·91
1874.........	81·90	10·12	0·30	6·90
1875.........	86·31	12·87	0·08	0·74
1876.........	84·03	14·99	0·05	0·93
1877.........	82·65	16·50	—	0·85
1878.........	80·88	17·29	—	1·83
1879........	76·94	20·76	0·07	2·23
1880.........	76·43	21·81	0·08	1·68
1881........	77·33	21·66	0·08	0 93
1882	72·88	25·43	0·24	1·45
1883......	70·27	26·66	0 90	2·17
1884.........	67·22	29·55	1·03	2 20
1885.........	65·84	30·35	2·00	1·81
1886.........	62 99	31·85	3·10	2·06
1887.........	54·00	38·15	5·89	1·96
1888......	47·46	40·34	10·10	2·10
1889...... ...	39·88	42·93	14·70	2·49

In this connection Table XXXIII. will be of interest.

It should be pointed out that of the China tea imported a large quantity is re-exported, while the bulk of the East Indian tea is retained for home consumption; and further, that this preference for India and Ceylon tea increases, notwithstanding the considerably higher price —averages for 1889 showing China tea to cost about 7½d. a lb., India 10½d., and Ceylon 11d.

TEA IN JAPAN, NATAL, FIJI, AND PARAGUAY.

The tea plant not being indigenous to Japan was first introduced from China. Although known in Japan for more than a thousand years, tea has only gradually become the national beverage, attaining this position so late as the 14th century. Its first introduction may with justice be assigned to the early part of the 8th century (A.D.); then for a space of four hundred years its use seems to have dwindled almost completely away. A revival took place about 1200 A.D., by the planting of China tea in the island of Kiushiu, a spot particularly suited in soil and climate to its growth. Until about 1570, the tea-leaves were, immediately after picking, immersed for a moment in boiling water, and after having been dried in the sun converted into powder; "firing" came into notice about this time, and presently became general. About 1857, the Chinese methods of preparing "black" and "green" teas were adopted.

In Japan green tea in leaf is universally used. Powdered, or "flat" tea, which is the finest kind, and is at present a most expensive luxury, is reserved for rare and very special occasions. It is prepared by infusing the powder, and the liquor is drunk with the powder in suspension. According to a recent work on "Tea in Japan," by Mr. Y. Kozai, of the Tokio Chemical Laboratory, the method of making tea in that country would appear to vary with the quality and description.

Superior teas, by which are meant those costing there 5s. to 7s. a lb., are used by infusing the leaves for two minutes at a temperature of 120° to 150° F., the water having previously been boiled, and then allowed to cool in a separate vessel. Those called "medium" teas, which are probably the best we get from Japan, are treated with boiling water, and allowed to infuse one minute. The leaves are renewed for every infusion. Thus prepared, Japanese tea is of the colour of pale sherry or Sauterne, and constitutes a most refreshing and reviving beverage. Milk and sugar are not used with the best kinds, being liable to spoil the delicate aroma, but with the rough, inferior kinds both milk and sugar are taken to cover the unpleasant roughness.

It is considered an unpardonable breach of good manners to omit to offer tea to a visitor immediately on his arrival. Even in shops the customer is served with tea before the goods are displayed to him, and this does not by any means oblige him to make a purchase.

As pointed out above, only the lower qualities of tea are exported, and these, according to Mr. Kozai, are often slightly sophisticated, being "faced," or else mixed with other plentiful and harmless leaves. None of these substitutes, however, contain theine, though some have tannin in their composition. The Japanese and Chinese do not consider Europeans connoisseurs on the subject of tea, and much prefer their own growths to those of India or Ceylon; but no doubt the diminished exports convince them that their views of what constitutes good tea will not have any effect on those who have come to the conclusion that Indian tea is preferable.

Natal.—In 1884, over 50,000 lbs. were produced and disposed of in the local markets. The samples shown at the Health Exhibition were indicative of future success. They were well made, and betokened careful supervision, but perhaps they were a little too highly "fired."

Fiji.—Excellent tea has been produced; however, the industry is yet quite undeveloped, and beyond growing specimens for comparison with other growths, nothing has been done to make the growth of tea a branch of commerce.

The name "tea" has been popularly applied to many other plants, the principal being:—

Abyssinian or Arabian	(leaves of *Catha edulis*).
Appalachian	(,, *Vibernum cassinoides*).
Australian	(,, *Leptospermum*).
Tasmanian	(,, *L. lanigerum*).
Malay	(,, *Glaphira nitida*).
Bourbon	(,, *Angræcum fragrans*).
Brazilian	(,, *Stachytarpha jamaicensis*).

TABLE XXXIV.—TEA.—UNITED KINGDOM.

Imports.					Consumption.	
Year.	British East Indies.	China (Hong Kong and Macao).	Other countries.	Total.	Lbs.	Pounds per head.
	lbs.	lbs.	lbs.			
1873..	20.326,882	133,307,196	8,710,317	162,344,395	132,022,155	4·1
1874..	18,440,494	131,669,998	11,492,918	161,603,410	137,422,563	4·2
1875..	25,784,866	170.966,836	1,525.570	198,277,272	145,458,120	4·4
1876..	28,126,854	155,897,192	1,674,144	185,698,190	149,131,779	4·4
1877..	30,957,295	154,996,561	1,561,428	187.515,284	151,275,237	4·5
1878..	35,563,503	166,190.545	3,707,235	205,461,283	157,691,762	4·6
1879..	39,236,433	141,435,474	3,838,472	184,510,379	160,652,187	4·6
1880..	45,530,728	158,195,142	3,245,700	206,971,570	158,570,334	4·5
1881..	46,054,392	164,541,989	1,866,196	212,462,577	160,225,789	4·5
1882..	53,927,998	154,081,777	3,070,587	211,080,362	165,079,881	4·6
1883..	60,994,402	156,170,385	4,840,732	222,005,519	170,812,697	4·8
1884..	66,084,947	144,410,328	4,716,839	215,212,114	175,097,983	4·6
1885..	68,635,100	139,838,344	3,901,927	212,375,371	182,455,982	5·0
1886..	80,987,351	145,111,596	4,796,345	230,895,292	178,894,151	4·9
1887..	97,830,117	119,739,116	5,194,054	222,763,287	183,635,885	4·9
1888..	113,004,692	105,424,271	5,189,515	223,618,478	185,556,214	4·9
1889..	127,160,409	88,848,574	5,593,677	221,602,660	185,621,800	4·9

TABLE XXXV.—CHINA TEAS.

	LEAF.	LIQUOR, FLAVOUR, &C.
Kaisows	Rather curly, reddish-black colour.	Bright, with rather deep colour, rich, fresh, good life. Finest falling off for some years; this year there is a revival, and they are arriving in considerable quantities.
,, Ching-Wo	Not so red, blacker, more curly...	Bright, paler in colour, more flavour, but cools down thin and often weak also.
,, Saryune	More open than two previous, and redder.	Clear, bright liquor, deep in colour, thick with good strength; rather rich flavour, difficult to describe, but well known in the trade.
,, Siftings, or Broken Leaf	Reddish-black	Thick, dark, full, more or less dead. Used for giving "body" to blended teas.
Moning	Greyish-black, curly, more or less "tipped."	In new season often pale and clear; in old seasons and according to class (Ning-chow, Oonfa, Keemun, and Kintuck) much darker, but bright. Full, more syrupy than Kaisow, smooth silky flavour. Very slight inclination to malt or tar flavour in some seasons.
Souchong (Lapsang)	Almost dead black, large, loose in make, slight curl.	Clear, bright, thin, delicate (slightly tarry) flavour. Finest (difficult to obtain for years past); are very pleasant by themselves; they are finest and most delicate of black leaf teas. Used also to flavour high priced and delicate blends.
Moning Siftings, or Broken Leaf.	Greyish-black	Dark, thick; soft smooth flavour, but dead—only used for giving body to blends.
Paklin	Small, reddish-black, tightly twisted and curly.	Clear, bright, fair body; fine fresh, rather delicate flavour, a pretty tea in appearance, pleasant by itself.
Hoyune	Rather small, curly, with a greyish-black to black colour.	Dark and thick (rather a deep red), very strong pungent tea; often a coarse, strong, and very tarry flavour—used for blending.
Oolong	Rough, coarse in make, with a somewhat greenish appearance.	Very clear and pale, strong, pungent, slightly bitter. In England used in small quantities solely for blending purposes, but in China the finest quality is extensively used by itself.
Scented Orange Pekoe (Canton) do. (Fow-Chow)	Long spider leaf, } Dark green. Small curly leaf. } Dark green.	Very clear, pale, almost a light straw colour; very strong, with full scented flavour; used only in blends. Scent imparted in process of curing mostly by use of a flower called Qui Fâ, resembling English jasmine.
Scented Caper	Small, shotty, some black and glazed, others greenish-black.	Clear, rather pale, strong, full scented flavour, not quite so pungent as Scented Orange Pekoe, and often coarser; used solely in flavouring. Scent imparted.
Hyson	Rather long, slight curl, fairly well twisted, silvery-green leaf.	Clear, pale, pungent, with sharp strong flavour, a little coarse; used for giving "life" and flavour to black teas. Now little used in England.
Young Hyson	Small, tightly twisted, curly; lightish green colour.	Clear, pale, straw colour, pungent, and more delicate in flavour than a Hyson.
Gunpowder	Small, short, tightly rolled, good green colour.	Clear, pale, straw colour, pungent, with rather a sharp delicate flavour, just inclined to be a shade bitter. Used for mixing with black teas.
Imperial	Large, often rather tightly rolled leaf, sometimes loose in make; green, or bluish-green.	Similar to last, pungent, coarser in flavour. Used for mixing with black teas.
Twankay	Rough flaked, green, lowest kind of "green" tea.	Rather muddy or dirty straw colour, pungent, with coarse common flavour. Used to mix with common kinds of black tea.

INDIAN TEAS.

	LEAF.	LIQUOR, FLAVOUR, &C.
1 Flowery Pekoe 2. Orange do. 3. Pekoe.	1 and 2 are smaller and much more full of tips and more curly than 3; from a grey black to black, more or less covered with white or orange tips.	Bright rich colour; great strength and sharp pungent flavour. The two first are more delicate, not so rasping as a Pekoe. These three are often used by themselves, but more frequently for giving life, sharpness, and flavour to China teas.
Broken Pekoe	Often more full of tips than previous three.	Much darker in colour than a Pekoe or full-leaved tea, and thicker—more body—very full in flavour, but without the strength or life of the previous lot. Used to give body to blends.
Pekoe Souchong	Not well enough made for a Pekoe, and coarser; the tips and tight twist place it above Souchong.	Clear, bright, strong, sharp, but a little coarse. A useful tea for "fetching up" medium teas—China teas especially.
Souchong	Large, coarse, rough; dead grey black colour.	Clear, strong, rough, rasping flavour, used only in blends—especially with China and Ceylon teas.
Broken Souchong. Pekoe Fannings. Dust.		Dark, thicker than from a full leaf, but not so strong; more or less coarse, and common in flavour.

CEYLON TEAS.

Orange Pekoe. Pekoe.	Rather smaller than Indian tea of this class, with a more dead black colour, and the tips more orange or golden.	Bright, rich colour, thick, full, rather fruity flavour, delicate and pleasant to drink by themselves; also largely used for flavouring blends.
Broken Pekoe	Siftings and broken parts of Pekoe and Orange Pekoe.	Dark in colour, thick in liquor, full fruity flavour—not the "life" ("point") of the former. Used for giving body and flavour to blends.
Pekoe Souchong & Souchong	Curly, almost dead black colour, not so much tipped as Pekoe.	Bright and clear (fairly), not so much body as Pekoe or Broken Pekoe, but more pungent and sharper in flavour, more life, but coarser. Used largely for drinking by themselves, and also for blending.

DARJEELING TEA.

Orange Pekoe & Pekoe	Small, curly, tightly twisted, brownish-black colour, rather deep orange-tipped.	Rather a deep, rich colour, bright, fairly thick; smooth flavour, but rich, with an inclination to a nutty taste, very delicate and pleasant to drink by itself. Also used for giving flavour to blends.
Pekoe Souchong & Souchong	Larger and looser than former with a brownish-black to black colour; more or less orange-tipped.	Rich, bright, good body, full, nutty; softer in liquor than the Assam Souchongs. Used by itself; also for giving body and flavour to blends.
Broken Pekoe	Siftings from Orange Pekoe and Pekoe; brownish, often full of deep orange tips.	Deep, rich colour, fairly bright, soft drinking; full rich nutty flavour. Gives body and flavour to blends.

Paraguay Tea (or *maté*) is an infusion of the leaves of *Ilex paraguayensis*, and probably *I. gongonha* and *I. theezans*, which are prepared by roasting the branches on hurdles over a wood fire, and then beating the leaves to powder with sticks on a hard floor. Three kinds are distinguished—"caa-cuys" (the half-expanded leaf buds), "caa-miri" (leaf deprived of midrib), "caa-guaza" (whole-leaf and small branches roasted). The consumption reaches more than 8,000,000 lbs. yearly in South America.

TEA.—CONSUMPTION PER HEAD IN VARIOUS COUNTRIES.

1884-1885 (generally)	lbs.
Australian Colonies	7·66
New Zealand	7·23
Tasmania	5·35

	lbs.
Great Britain	5·02
Newfoundland	4·38
Canada	3·69
United States	1·30
Holland	1 05
Cape Colony	·90
Natal	·76
Russia	·61
Denmark	·37
Argentine Republic	·30
Persia	·13
Portugal	·12
Switzerland	·10
Norway	·09
Germany	·07
Morocco	·06
Belgium	·03
Sweden	·03
Austria	·02
Spain	·01

Brief Description of the Principal kinds of Commercial Tea.

China.—Kaisows and Monings are not so pungent and full flavoured as Indian teas.

Kaisows have more life than Monings, and are altogether fresher in the cup.

Monings are soft, smooth drinking teas, and, in some seasons, have a slight inclination to a "malty" or "tarry" flavour.

Oolongs are pungent, faintly "herby" or bitter, and in small quantities give life to blends.

Scented Orange Pekoe and Scented Caper both give a pale strong tea, used solely in flavouring blends.

Souchongs are perhaps the finest of black leaf teas, possessing a really delicate flavour, and suitable for use alone or in blends.

Gunpowder, Hyson, Young Hyson, Imperial, and Twankay, are all green teas, used for giving flavour and life to blends.

Assam or Indian are much more pungent than China teas, rougher in flavour, and are principally of use in mixing with the milder teas of China and Ceylon.

Darjeelings are powerful, but softer in flavour than Assams, and more delicate; very suitable for drinking by themselves.

Ceylons, fairly thick; as a rule they have not the strength and pungency of Indian teas. They possess a rich fruity flavour, and are extensively used both blended and alone.

Broken-leaf teas of all kinds are always darker in liquor, thicker (more body) than full-leaf teas. They are not so fine in flavour, and have not the life of whole-leaf tea.

China teas keep, and retain their flavour, much better than Darjeelings and Ceylons.

The keeping quality of Ceylon tea is generally very bad. It cannot be relied upon from one month to another; and on account of its being imperfectly cured, it is desirable that after a chest is once opened the tea be at once mixed off or used as quickly as possible.

Tea of all kinds quickly absorbs and retains the flavour of anything it comes in contact with, and always ought to be kept by itself and as air-tight as possible.

The tarry flavour so pronounced in several of the varieties is not to be looked upon as a natural characteristic of the tea itself, but rather as taking its origin in the process of drying, where in many cases the smoke from the fire permeates the moist leaves; in like manner the scented teas derive their odours from extraneous perfumes.

General Notes.

Department of Science and Art. — Her Majesty has been graciously pleased to command that the Government Institution now known as the Normal School of Science and Royal School of Mines shall in future be called the Royal College of Science, London.

A Ship Railway in Canada.—A project has been announced in Canada which, if successfully carried out, will effect a great change in the lake, river, and canal navigation between the St. Lawrence and the west ports of Superior. Already the Sault Ste Marie canal connecting Huron and Superior has had its lock three times enlarged since its formation, and there is one now in construction 800 feet long, and 100 feet wide. The traffic there exceeds that of the Suez Canal. The project is to avoid the circuitous route between Ontario and Huron *viâ* Erie by connecting these two lakes by means of a ship railway commencing at Toronto. The distance by the route proposed is 69 miles. The elevation of the highest ridge to be passed is 664 feet above the level of Ontario, the heaviest grades on the north side being 30 feet to the mile, and on the south 20 feet. The calculations are that, with three powerful locomotives, vessels of 2,000 tons could be carried at the rate of 10 miles an hour, so that the journey from the Ontario dock to the Huron dock would occupy about seven hours. The distance saved by not going through Lake Erie would be about 400 miles. The estimated cost of the railway is set down at 12 million dollars.

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FRIDAY, NOVEMBER 7, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

ARRANGEMENTS FOR THE SESSION.

The First Meeting of the One Hundred and Thirty-seventh Session of the Society will be held on Wednesday, the 19th November, when the Opening Address will be delivered by the Attorney-General, M.P., Chairman of the Council. Previous to Christmas, there will be four Ordinary Meetings, in addition to the Opening Meeting. The following arrangements have been made:—

Ordinary Meetings.

November 19.—Opening Address by the Attorney-General, M.P., Chairman of the Council.

November 26.—Francis Galton, F.R.S., "Physical Tests in Competitive Examinations."

December 3.—James Dredge, "The Chicago Exhibition, 1893."

December 10.—F. Bailey, "Electric Lighting Progress in London."

December 17.—George Davison, "Impressionism in Photography."

Papers for which no dates have as yet been fixed:—

"Methods and Processes of the Ordnance Survey." By Colonel Sir Charles Wilson, K.C.B., K.C.M.G., F.R.S.

"Lands available for Colonisation." By E. J. Ravenstein.

"Fast and Fugitive Dyes." By Prof. J. J. Hummel.

"Photography in Aniline Colours." By A. G. Green, C. F. Cross, and E. J. Bevan.

"The Use of Petroleum in Prime Motors." By William Robinson.

"Illustrated Journalism." By Carmichael Thomas.

"The Growing Need for Decimal Coinage, Weights, and Measures." By T. Emerson Dowson.

"Sgraffito." By Heywood Sumner.

"Glass Painting." By H. Arthur Kennedy.

"Electricity in relation to the Human Body." By H. Newman Lawrence and Arthur Harries, M.D.

"Steam Lifeboats." By J. F. Green.

"The Sources of Petroleum." By Wm. Topley, F.R.S.

"The Proposed Irish Channel Tunnel." By Sir Roper Lethbridge, M.P.

Foreign and Colonial Section.

The meetings of this Section will take place on the following Tuesday afternoons, at Half-past Four o'clock:—

January 20; February 17; March 17; April 21; May 5, 26.

Indian Section.

The meetings of this Section will take place on the following Thursday afternoons, at Half-past Four o'clock:—

January 22; February 26; March 12; April 9, 30; May 28.

Applied Art Section.

The meetings of this Section will take place on the following Tuesday evenings, at Eight o'clock:—

January 27; February 10; March 10, 24; April 14; May 12.

Cantor Lectures.

The following Courses of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

Prof. Vivian B. Lewes, "Gaseous Illuminants." Five lectures.
November 25; December 1, 8, 15, 22.

A. J. Hipkins, F.S.A., "The Construction and Capabilities of Musical Instruments." Three lectures.
January 26; February 2, 9.

Gisbert Kapp, "The Electric Transmission of Power." Three lectures.
February 16, 23; March 2.

Prof. R. Meldola, F.R.S., "Photographic Chemistry." Three lectures.
March 9, 16, 23.

HUGH STANNUS, F.R.I.B.A., "The Decorative Treatment of Natural Foliage." Four lectures.

April 13, 20, 27; May 4.

JUVENILE LECTURES.

Two Lectures, suitable for a juvenile audience, will be delivered by E. B. POULTON, M.A., on "Mimicry in Animals," on Wednesday evenings, December 31, 1890, and January 7, 1891, at Seven o'clock.

Proceedings of the Society.

CANTOR LECTURES.

SUGAR, COFFEE, TEA, AND COCOA, THEIR ORIGIN, PREPARATION, AND USES.

BY RICHARD BANNISTER.

Lecture IV.—Delivered May 19, 1890,

COCOA: ITS NAME.

The family from which cocoa is derived was called by Linnæus, *Theo-broma*, derived from the Greek Theos (God) and Broma (food), as showing his great appreciation of the nourishing drink derived from it. The Mexicans and Spanish called the tree and the seeds yielded by it cacao, but this word has now been corrupted into cocoa, and I am unable to trace the successive steps of this change. The word cocoa introduces an element of confusion on account of the fruit of the cocoa palm (*Cocos nucifera*), which is well known here, being called by the same name, and some have thought in consequence that the origin of the cocoa-nut and the cacao was the same. To prevent this confusion of ideas, the fruit of the cocoa palm has sometimes been spelt coker, and in some official and commercial documents this spelling can be found. The words cacao and chocolate are of Mexican origin, and it has been surmised that as the latter word was given to mixtures of cocoa with sugar and spices, it was derived from "chocolatl," the nearest approach to an expression in letters of the sound made by the mortar and pestle during the preparation of the mixture.

It is certainly easier to use the word cocoa than cacao, and though the latter is strictly correct, the former by usage has become the popular word to identify the preparations of the seeds of the *Theobroma Cacao* of Linnæus, although officinally the latter name appears.

The opinion Linnæus formed of the qualities of this drink was certainly a very high one, and in sketching the history of our subject it will be seen that there is an air of romance surrounding it, and we shall feel that others besides Linnæus held cocoa and its preparations in esteem almost approaching veneration.

COCOA, OR CACAO: ITS COMMERCIAL HISTORY.

Cocoa being obtained from the seeds of a tree which is a native of tropical America and indigenous to Mexico it follows that for our first knowledge of it we are indebted to the discoverers of America, and especially to Hernando Cortez, who afterwards conquered Mexico in 1521. As Mexico thus became a tributary of Spain, cocoa was introduced into Europe long before either tea or coffee, and the manufacture of preparations of cocoa was carried on secretly in Spain, and distributed afterwards for consumption in neighbouring countries. The Mexicans appear to have used the seeds or nut of the cocoa as coins, and Peter Martyr gave them, on this account, the name *Amygdalæ pecuniariæ*. Cocoa was also used as a food, and the beverage produced by infusing the broken seeds, or nibs, was much esteemed, one writer going as far as to say that it was "deeply appreciated by the Mexicans, with whom it was held in religious veneration." Cortez, when settled in Mexico, sent home to his master, Charles V., the most important commercial products of the country he had subjugated, and in this consignment cocoa occupied a very prominent position. Its virtues were set forth with minute detail, and the medical men of the day who became acquainted with it were not slow to extol these virtues and to recommend it to those patients possessing wealth enough to obtain it.

Hoffman treated of it in a monograph entitled "Potus Chocolati." He considered it very beneficial in many diseases, and pointed out that Cardinal Richelieu had been cured of a dangerous disease by its use. The cure of so august a patient by means of cocoa was a good advertisement for the new remedy, and as it was both pleasant and popular, it soon grew into use as a medicine and also as a food.

The Spaniards conquered Peru in 1533, and from Prescott's "History of the Conquest of Peru" we learn much respecting the country at the time of the conquest, especially that cocoa was in cultivation before that event, and also the impression made on the mind of Pizarro and his soldiers as they sailed along the coast. "They saw broad patches of cultivated land disclosing hill-sides covered with the yellow maize and potato, or chequered in the lower levels with blooming plantations of cacao."

The same writer, in his "History of the Conquest of Mexico," dwells upon the use made of cocoa by the Mexicans, and though the account must be greatly exaggerated, yet there is no doubt that both in Mexico and Peru, and also in the countries lying between, cocoa was extensively used, and in Mexico it was a royal drink. Prescott says, "The emperor was exceedingly fond of it, to judge from the quantity, no less than fifty jars or pitchers being prepared for his own daily consumption." This statement is evidently made on the assertion of another writer (Bernal Diaz), who records that "What I myself saw was that they brought him upwards of fifty great jars filled with good cacao with its froth, and of which he partook." Such words will bear the meaning that this quantity was made for the Emperor and his court, and even this liberal rendering must convey the idea that the statement was a gross exaggeration.

Evidence is available to prove that different towns and cities of the empire paid cocoa as tribute. Thus, one city is said to have supplied "20 chests of ground chocolate;" another "80 loads of red chocolate;" a third "200 loads of chocolate."

The historian Torquemada gives, on the authority of the royal account-book, which came into his possession, the annual consumption of cocoa in the palace at Mexico as 2,744,000 fanegas. A fanega weighed 110 lbs. Spanish, and is therefore equal to about an English hundredweight. Humboldt estimated that in 1806 from six to nine million pounds of cocoa were consumed in Spain, and from fourteen to seventeen million pounds in the remainder of Europe. A comparison of these figures brings out the extraordinary fact that the quantity of cocoa alleged to have been consumed in the Emperor's palace was thirteen times more than that consumed in Europe 250 years afterwards. Evidently exaggeration abounded in the statements derived from Mexican sources, but whether they were made by the Mexicans or their conquerors is difficult to decide.

It is apparent, however, that the Mexicans did not confine themselves to the use of cocoa without other admixture; and from the materials used by them it can be gathered that they had to surmount the same difficulties as presented themselves to the cocoa manufacturers of modern times, and had to modify the strong flavour of the cocoa as well as cover the flavour and physical characteristics of the fat.

The beverage which was called chocolatl was "cocoa flavoured with vanilla and other spices, and so prepared as to be reduced to a froth of the consistency of honey, which gradually dissolved in the mouth, and was taken cold." This beverage was served to Royalty "in golden goblets, with spoons of the same metal, or of tortoise-shell, finely wrought."

In Rees' Cyclopædia (1819), it is stated that the South American Indians and early Spanish settlers prepared the chocolatl, or chocolate, for use by using the cocoa-nut with maize and raw sugar, as expressed from the canes, with a little annatto to give it a colour. "Of these four drugs ground between two stones, and mixed together in a certain proportion, they made a kind of bread, which served them equally for common food and for drink; eating it dry when hungry, and steeping it in hot water when thirsty. The Indians, to one pound of the roasted nuts, put half a pound of sugar dissolved in rose-water, and half a pound of flour, or maize."

The Spaniards, who settled in the countries they had conquered, soon became accustomed to the manners and habits of the natives, and cocoa, and preparations into which it entered, became popular articles of diet; and the mother country was soon a large user of the cocoa, either as such or when mixed with other ingredients. The monks are credited with introducing it into Germany from Spain, and afterwards into France and other countries of Europe. A German, named Joan Franz Rauch, wrote against its use in 1624.

In 1657, cocoa, under the name of chocolate, was publicly sold in London. An advertisement appeared in the *Public Advertizer* of Tuesday, June 16th, and for the six following days, that "In Bishopsgate-street, in Queen's Head-alley, at a Frenchman's house, is an excellent West India drink called chocolate to be sold, where you may have it ready at any time, and also unmade at reasonable rates." A few years later other houses were opened for the sale of cocoa and preparations of cocoa, and with coffee and tea it soon became a favourite with the rich and fashionable. "Chocolate paste was sold in 1660 a from ten to fifteen shillings a pound. Imitations of the best qualities of chocolate were sold at cheaper rates; and in 1662, "at the coffee-house in Exchange-alley," "chocolatta" was sold by retail, the ordinary pound boxes at two shillings each.

The habits and fashions of life of the Restoration led the people to think less of home and more of club life; consequently any business which pandered to the development of this new idea became more or less popular, and the cocoa and coffee-houses of Charles II.'s reign were important institutions. The fashionable made them their regular lounging places, and the lovers of novelties patronized the new foreign drinks. The result was that these houses soon became mixed up with politics, and certain of them became identified with political parties during the 18th century. The chocolate house known as the "Cocoa Tree," in St. James'-street, was one of the most important, and was frequented by the Tory party. Defoe says, "A Whig will no more go to the 'Cocoa Tree' or Ozinda's (another chocolate-house in the neighbourhood) than a Tory will be seen at the coffee-house of St. James'." Clubs were formed having distinctive names, and the members met at these cocoa-houses. A famous one possessed the name of the "Cocoa Tree Club," and Byron was a member of it. At this period gambling became associated with the clubs, and it is recorded by Horace Walpole in 1780 that "within this week there has been a cast at hazard at the 'Cocoa Tree,' the difference of which amounted to an hundred and fourscore thousand pounds." Fortunately for these non-intoxicating beverages, club life developed more exclusiveness, while tea and coffee-houses continued to be places of resort for refreshment. Politicians, humourists, and others who had used these houses became more exclusive, and established club houses of their own, in which persons possessing certain distinctive qualifications could be admitted to membership, and thus they were able to meet together for a common object. This phase of club-life received a fresh development after the termination of the great French war, ending with Waterloo. Military and naval officers were not needed, and many of them were therefore placed on half-pay. On such diminished incomes they found it difficult to live, and in these circumstances a movement was started to establish clubs to cheapen the cost of living. This was carried out, and the modern club has become more intimately associated with the supply of food and intoxicants than with cocoa, tea, and similar beverages. As time went on, these non-intoxicant stimulating drinks were looked upon as necessaries of life, and, on account of the public demand for them, constituted part of the ordinary food of the people; their sale has therefore passed into the hands of the grocer, and they are almost entirely divorced from their improper alliance with the club and fashionable life of the last century. Their common use in the public dietary of this country has caused the political economist to make a grand distinction between them and the ordinary intoxicant as regards the fiscal duties which they should bear. Every politician of the last generation has made it a part of his financial policy to tax spirits to their utmost capacity, and to reduce the duties on tea, coffee, cocoa, and sugar. The effect of this policy has been to cheapen these necessaries of life, and to raise the price of intoxicants, with the result given in the Table at the end, which demonstrates the fact that cocoa has, under such a system, largely increased in consumption, whilst intoxicants have either remained stationary or diminished. It is mainly due to this policy that cocoa has so largely increased in consumption during the last fifty years, for this article of commerce has gone through many vicissitudes, being, in 1793, charged with a duty of twelve guineas per cwt., coupled with a further Customs duty of 11s. 11½d. per cwt. (Now it is 1d. per lb. on cocoa, 2s. per cwt. on husks, and 2d. per lb. on chocolate.) Such a tax was prohibitive, and it not only stopped its importation into England, but also acted as a deterrent to our Colonies from engaging in growing cocoa. The result has been that, in those Colonies where the cocoa tree would grow it was allowed to die out, and the sugar industry was made the one stock crop. When ruin overtook the sugar-grower through fiscal changes and European competition, the cocoa plantations had disappeared through neglect, and at the present time, with the exception of Trinidad and Grenada, our West India Islands do not practically produce cocoa as an article of commerce, although cocoa growing is now being carried on on an experimental scale. Martius states that a distinct species of cocoa, known as *Theobroma Sylvestre*, was found wild in Jamaica; and two hundred years ago cocoa cultivation had got a firm hold on the island. Long, in his "History of Jamaica" (1774), narrates the extent of the cultivation of the cocoa, and says that in 1671 there were sixty-five walks in bearing, and many new ones in cultivation. Some time afterwards these trees were destroyed by a hurricane which visited the island, and new planting was neglected. It is likely that the English, who took Jamaica from the Spanish in 1655, did not look upon cocoa cultivation with favour, on account of their ignorance of its qualities, and of not having the same outlet for it as an article of commerce; but from whatever cause the abandonment of the cultivation arose, it has been a serious loss to Jamaica, and indirectly so to ourselves. Efforts are now being made to restore cocoa cultivation, especially as cocoa commands a good price, and is every year in greater demand in Europe and the United States. This popularity is no doubt mainly due to the progress made in the preparation of the article for consumption.

Cocoa in its natural state contains a large proportion of fat, so that it cannot be taken by those suffering from weak digestion. Moreover, the presence of so much fat prevents the easy solution of the naturally soluble portions of the cocoa, which are more or less locked up in the fat. This difficulty was encountered and overcome by the Indians and Mexicans in the same way as our cocoa manufacturers first overcame it, viz., by adding to the cocoa in a powdered condition sugar and starch, and thus diluting the cocoa to an extent which permits of its use even by the delicate. Another method is to remove by pressure a large quantity of the fat, and by subsequent treatment, which is generally a secret process, to make the cocoa thus deprived of a portion of its fat more soluble in hot water. When treating of the composition of cocoa, it will be seen that it is a very nutritious article of food, and modern chemical analysis has shown that the estimation in which cocoa was held as a food by the inhabitants of the countries in which it was first produced rested on scientific as well as on practical grounds. It would appear that our cocoa manufacturers are now working on the same lines as the natives of Central America did 300 years ago, and though good machinery and manipulative skill give great advantages to the modern manufacturer, yet the addition of sugar and starch, and the flavouring with vanilla and other spices, are only imitations of what was done in early times to make the cocoa more serviceable as a food, better suited to our requirements as an ordinary beverage, and adapted for consumption as a condiment or sweetmeat by the young and old.

THE PLANT AND ITS CULTIVATION.

The cocoa and chocolate of commerce are made from the seeds of a tropical evergreen shrub, belonging to the order *Byttneriaceæ* or *Sterculiaceæ*. The family to which it belongs is, as I have stated, called *Theobroma*, and the particular species most esteemed and cultivated is the *Theobroma cacao*. Originally a native of tropical America, it is now grown in the tropics of both hemispheres, in order to furnish a supply equal to the large demand which its valuable properties have created. In height this shrub grows from 15 to 40 feet, its average being about 25 feet; in plantations, however, it rarely exceeds 18 feet. It flourishes nearly up to altitudes of 2,000 feet, and in any latitude not exceeding 25° from the equator. The bark is of a rich brown colour, which becomes darker with age. The branches are almost void of leaves except at the ends; there the leaves are alternate and stalked, and in size about 8 by 2½ inches. The leaves, when young, are exceedingly delicate, and of a light pink colour. The flowers are small, odourless, and of a saffron or pink colour. The quantity of blossom is much greater than the amount of fruit which might be expected from it, as many flowers fall off. They are often found growing thickly on the old wood of the shrub where before leaf-axils have been. The fruit is a pod in shape like a pear, but somewhat elongated, and grows singly or in clusters; as a rule, one pod is obtained from each cluster of flowers. They measure from 5 to 10 inches in length, and vary in colour from lemon to purple, according to the variety. The pod is rather thick, and has no taste; its surface has generally ten shallow grooves down its length, with blunt rounded ridges, the latter often warty. The pericarp, in which the seeds lie, has five cells, the exterior of which is tough, fleshy matter about ½ to ¾-inch thick. The seeds are rather closely packed in pulp, and lie in tiers in these cells; they are ovate, flattened, about the size and shape of haricot beans or olives, and covered with a thin greyish brown or red friable shell. The seed has a light and agreeable smell; its taste is bitter, oily, and rather rough, though not unpleasant. The pulp surrounding the seeds is a rose-coloured, spongy substance, something like the flesh of water-melons. Each pod contains from 20 to 40 beans, disposed in five rows or tiers, as above stated. The variety grown in Central America contains sometimes as many as 50 seeds, while that cultivated in the West Indian Islands and Demerara only yields 10 to 15. On cutting a seed longitudinally, it is found to consist of (1) the cotyledons, a crumpled, pale crimson or purple mass, divided into several unequal portions adhering together but easily separated, and constituting the bulk of the seed; and (2) of a small elongated white body nearer the thicker end of the seed—the embryo.

The species *T. cacao* can be now subdivided into a great number of varieties—the result of centuries of cultivation and selection. These varieties have each special characteristics, with which the planter should be well acquainted; systematic cultivation, to be successful, must take into account such points as crop-bearing capacity, size of trees, particular soil and situation necessary, required degree of shade, and the final product, *i.e.*, the character and flavour of the bean. The finest variety is that known as the "Creole," or, as the Spanish-Americans call it, "criollo," and is grown chiefly in Venezuela. It has small pods, and the beans are almost spherical. In taste, the latter are somewhat bitter, but soft, oily, and pleasant. On an average, ten or twelve of these pods yield a little over a pound of cocoa.

Another variety under culture in Venezuela is the "Caracas," which is much esteemed by many; its pods are red—those of the "Creole" are yellow. The beans are more spongy than those of the "Creole" kind—fourteen to sixteen pods yielding about 1 lb. of cocoa.

There is another variety known as the *Cacao forastero*—forastero meaning "foreign"—more robust and hardy, and chiefly grown in the West Indian Islands. There are some twelve or thirteen forms of this variety, each existing in two kinds, red and yellow—from the colour of the pods.

In planting cacao, two methods are employed, according to circumstances. Where good and new land and plenty of seed are available, the seeds are sown direct. In other cases, nurseries are kept to supply young plants for transplantation to the projected cocoa-field. The nursery must be a piece of choice, moist ground, and the seeds carefully selected; when the plants are 12 to 18 inches high, they are removed to the cocoa-field, which must be flat, rich land, and easily watered. A gentle slope, affording shelter from cold winds, is best. The necessary shading is produced by planting coral-bean, plantain, coffee, or manioc. In the second year, blossoms appear on the young cocoa trees, but these are stripped off, the trees not being allowed to bear till the fourth or fifth year. The average number of trees per acre is 900, each of which, in a state of maturity, yields 4-6 lbs., though three times this amount has been known in single cases. A healthy tree will bear for forty or fifty years.

COCOA: HARVESTING AND PREPARATION FOR THE MARKET.

The cocoa tree bears fruit all the year round, but the chief seasons for harvesting are in the months of May and June, and again in October and November. In Venezuela these two periods give the names "St. John's" and "Christmas" respectively to the crops. At the time of harvesting great care is taken that only the ripe pods shall be gathered, and that in removing these pods no damage shall be done to the trees. The reason for gathering only ripe fruit is obvious, for as the commercial value of cocoa mainly depends upon uniformity of the colour and size of the beans, and as this uniformity can be best secured by gathering the ripe pods only, the careful grower uses every precaution to gather the pods only when the seed is ripe. The colour of the pod will generally reveal the condition of the seed, but the fruit growing within reach of the gatherer is gently tapped to see if the seeds have shrunk from the pulp in which they were embedded and become detached. If so, they are in a fit state to be harvested.

These pods are removed by severing the stalk with a sharp instrument. The portion of stalk adhering to the tree eventually dries up and falls off, leaving the tree sound. The pods are attached to a soft point in the tree which was originally the axil of a leaf, and from such soft points all future flowers will spring. If, however, the pod is torn away, this soft tender part is bruised, and the injury causes the tree to become afterwards sterile at the particular point damaged.

The pods when cut off are collected into heaps, and as soon as it is convenient (generally the next day) persons are told off to the duty of separating the beans from the pulpy husk containing them. This operation is generally done by the pods being cut open with a cutlass, and by the removal of the seeds from the adherent tissue in which they are embedded. Great care is taken to separate all black, unsound, or unripe beans, and when this has been done, the seeds are removed to the "sweating" or curing house.

This operation, which requires great skill and care, is one on which the commercial value of the finished beans chiefly turns.

The three points aimed at in conducting the sweating operation are—

1. The loosening of the adherent pulp.
2. The removal or the modification of the bitter principle of the bean by fermentation.
3. The colouration of the beans to a rich mahogany tint.

The beans have to be put together to ferment to a given temperature, and the method of procedure is modified to suit the requirements of each individual case. In large plantations there is a house set apart for sweating the seeds, but in small places movable vessels are requisitioned for the purpose, or the seeds are put into a trench, and covered with plaintain leaves to keep up the temperature during the incipient stage of the fermentation. The saccharine matter of the pulp soon commences to ferment, but this fermentation must be kept under complete control, or the beans will be done either too much or too little. The weather has a good deal to do with the fermentation, and during a time of rain there is a tendency for the fermentation to become violent, and then the seeds will assume a dark or black colour. A juice runs out from the pulp, and this is often collected and converted into a common kind of vinegar. The floor should, however, be kept sweet and clean, for the nibs have a tendency to acquire any particular flavour of the sweating-house. The duration of the fermentation is regulated by circumstances, but it generally lasts from two to seven days.

When the fermentation is complete, and the coverings removed, it will be noted that the mass of cocoa remains hot, the pulpy matter surrounding the seeds has become more or less slimy, and can be readily removed. The bean itself has also altered in character. Its bitterness has become distinctly modified, and the bright reddish colour has changed to a deep brown. The beans are then carefully removed from the pulp and are covered with red earth or sand, and heaped together for further fermentation. Next day they are again dusted with earth and allowed to cool. The red earth dries the mucilage adhering to the bean, and by careful and systematic rubbing the beans put on a nice appearance, and have a colour which is certainly not quite natural.

Red earth is not always used for drying and colouring, but it is generally employed in Trinidad and Jamaica. When the cleaning and rubbing processes are completed, the beans are spread out on a tray to dry, and every part of the bean is sytematically exposed to the light. This operation is repeated till the seeds are properly air-dried and in a condition suitable for shipment.

Cocoa which is prepared without undergoing fermentation is distinguished by its pale skin, and this skin will not readily separate from the seed which it envelops. Its bitter taste only renders it suitable for use as cocoa in the cocoa mixtures containing starch and sugar. Its flavour and character unfit it for use in chocolate-making, and, as a matter of course, it commands a low price, as compared with fermented cocoa.

The cocoa industry has now become a very important one in this country, and great attention is therefore given to the selection of cocoa best suited to the class of trade carried on by each maker. The British manufacturer is not now satisfied to make the ordinary cocoas, and permit the French and Swiss manufacturer to flood the market with chocolate, creams, and other sweetmeats now in general demand. He has entered the field to produce all kinds his customers may require, and his success can be measured by the increased quantity of cocoa (raw) imported, as compared with the manufactured cocoa imported. The trade is generally in the hands of men who can command the capital required to conduct their business on the ready-money system. Such men buy in the best market; and as they use only the best of material, combined with first-rate knowledge of the manufacture of the articles in demand by the consuming public, they not only hold their own, but increase their trade, and the British cocoa trade has become a large and very lucrative industry. Cocoa is made up in all kinds of fancy forms and designs to attract the public taste and appetite, and it is not surprising that when presented in such forms and in such variety as at the present time, the industry should have increased by leaps and bounds, and become one of first importance as a home industry,

COCOA: ITS MANUFACTURE.

Cocoa as imported is not in a fit state for consumption without further treatment, and whatever may be the form it is made to assume as an article of commerce before passing into the hands of the public, the operation of roasting the seeds has to be performed on all alike. This roasting causes the husk enveloping the bean to become loose, develops a distinct aroma, and causes the seed to be friable. The process is one requiring great care and skill, and the workmen conducting the roasting must be men of wide experience, capable of acting on their own judgment as to the exact moment the bean is cooked. The roasting apparatus is in good establishments so closed in that the temperature inside can be registered on a thermometer, and thus the roasting can be carried out with greater exactness than when only dependent on the judgment of the roaster. The cylinders containing the beans during the roasting are made to rotate to ensure uniformity of cooking, but it has been found that this uniformity is more perfect if the beans in one roasting operation are of uniform size. To secure this object the beans are made to pass over sieves having apertures of different dimensions, and thus by a simple mechanical arrangement the beans are assorted according to size, and conveyed to suitable receptacles. Assorting and cleaning are effected in one operation, and the beans are afterwards roasted. After they are roasted—which is done between 500° and 600° F.—and cooled, they are conveyed to a machine, generally fixed at the top of the factory, which is employed to break down the seeds by fracturing the crisp husk, and pressing the beans sufficiently to make the sections of them part from one another, and become the "cocoa nibs" of commerce. The husk and nibs are carried down to a winnowing machine, in which the husk is effectually separated from the nib, and the nibs fall by their own weight into a sorting machine, which separates them into classes of nibs, each of uniform size.

This sorting is found useful in the operation of grinding, as the perfection of grinding consists in bringing the ground cocoa to a condition of smoothness which renders it free from grain or grittiness, and as uniform in consistence as it is possible to be. This grinding is done by millstones, so constructed that the nibs must pass constantly between them till they are thoroughly disintegrated, and if the nibs are to go into consumption as ground nibs in powder, the stones are kept cool during the operation.

As, however, nearly all the cocoa ground is afterwards made up into rock or flaked cocoa, chocolate cakes, or sent into consumption after having been deprived of a large portion of its fat, under such names as "extract" or "essence of cocoa," it is usual to keep the stones heated during the grinding. The heat causes the fat to melt, and in a very short time the crisp nibs become soft, and at last are reduced to a liquid state, which the uninitiated sometimes think has been caused by the addition of water. The composition of the natural nib indicates that heat only is required to bring about this condition of things, for a substance containing half its weight of pure fat melting at a temperature of about 84° F., can only require warmth to bring it into a liquid form when in a condition of fine disintegration.

As cocoa fat has no tendency to become rancid, the finely ground cocoa paste is, after the first grinding operation, run into blocks of suitable size, where it is allowed to cool. These blocks of pure cocoa are kept as stock for subsequent treatment, or are sold as such.

At the Admiralty victualling yards cocoa has for a very long time been prepared for the use of the Navy. About the year 1825 it was introduced as a substitute for gruel for breakfast. Then, and for seventeen years subsequently, the husk or shell was ground in with the nibs, as is now very often done in commerce, but as it was believed to have a bad effect on those who habitually used cocoa, in 1842-4 the shell was not ground in with the cocoa, and it is now sold to dealers for purposes which may be easily enough conjectured. Its market price is about £11 per ton, and as it contains some of the most valuable ingredients of the cocoa nib, it lends itself to adulteration, and very few samples of ordinary ground cocoa are free from it.

Navy cocoa being roasted, ground, and prepared in the victualling yards, is kept free from husk; and being, like many other manufactured foods entering into the sailor's dietary, home-made, the ingredients are of first-class quality.

Although this prepared cocoa, which is made up in two varieties, is called cocoa, both of them are doubtless chocolates. The first is mixed with 20 per cent. of good Demerara sugar, and the second with 20 per cent. of refined sugar and an equal amount of arrowroot. The first is called ordinary, and the second soluble cocoa.

The materials employed to produce these preparations undoubtedly furnish the Navy with an excellent article of diet, and it is gratifying to know that our sailors, who do so much to protect us and keep our homes free from foreign invasion, have food which is good in quality and also carefully prepared.

The operations principally carried on at a modern cocoa factory are chiefly for the purpose of giving the cocoa more solubility than it possesses when in the form of nib, either whole or ground into powder, and the successful attainment of this object promotes the present demand for cocoa and its derivatives. Those who have tried to make a beverage from the nibs themselves, will fully understand the difficulty encountered in carrying out this object. The long simmering, the quantity of fat separated, and the apparently weak extract obtained, all tend to make such a drink unpopular. The cost, too, is considerable, and, as a consequence, cocoa in the form of nib has, in the pure state, never been popular.

The manufacturer who first presented to the public the cocoa in powder, mixed with starch and sugar, and sold under the name of soluble cocoa, indirectly conferred a benefit of the highest value, because a typical, agreeable drink was thus prepared; and it has been through this channel that cocoa has become popularised, and the improvements in the manufacture so marked. As before stated, cocoa naturally contains too much fat to render it a suitable food for the dyspeptic, and those who prepared cocoa from the pure nib had either to let the infusion cool and take off the fat from the surface of the liquid, or else consume more fat than they could digest. The soluble, or homœopathic cocoa was made to meet these two difficulties. The cocoa was diluted by the addition of Iceland moss, or some form of starch and sugar. The sugar sweetened the liquid, and the starch, which was usually of a kind whose granules burst at a comparatively low temperature, formed a gelatinous menstruum in which the finely-ground cocoa was suspended. Such a mixture was said to be "soluble cocoa;" and because the cocoa was small in quantity, and did not readily settle at the bottom of the cup, the public believed that such was the case. The price at which these cocoas were sold must convince the most sceptical that the public had to pay very dearly for the sugar and starch present in them, and the eagerness with which cocoa manufacturers entered into this branch of trade showed it was a very profitable manufacture.

Further on is a Table containing the analyses of a number of these samples which were made in the Inland Revenue Laboratory, and their composition will demonstrate to you that from the small quantity of cocoa present in them there was no danger of any bad effects being felt by those who used them, from taking too much cocoa fat.

The mucilage from the starch or moss present in them led people to believe they possessed very nutritious properties, but their composition, when it became known, was not satisfactory to medical men, and an effort was made to produce a prepared cocoa which, being free from foreign ingredients, should contain less fat and be more soluble than ordinary cocoa. Both British and foreign manufacturers were keenly alive to the value of such a preparation, and tried to produce it. They have succeeded in doing so by removing, by heat and pressure, a considerable portion of the fat from the pure cocoa paste, and making the residual cocoa more soluble either by the addition of a small proportion of an alkali, or by further heating this residue. Almost every manufacturer of repute has a specialty of this kind, and from the enormous sale of these extracts, it is apparent that, although comparatively costly, they supply a public want.

Being specialties, each manufacturer has a secret method of his own for their manufacture, but this refers rather to the problem of increasing their solubility in boiling water than to the abstraction of the fat. The fat is abstracted by placing the pure cocoa paste in strong canvas bags and submitting them to hydraulic pressure of from 1,200 to 1,400 lbs. to the square inch. The cocoa butter escapes through a proper orifice, and the cake of pressed cocoa is turned out in a nearly dry condition, and is either subjected to heat or chemical treatment, as before stated.

The following Table shows the composition of some of these specialties:—

TABLE XXXVI.—Commercial Cocoa.

Kind.	Per-centage of					
	Moisture.	Fat.	Non-fatty Cocoa.	Ratio of fat to non-fatty Cocoa	Starch (added).	Sugar (added).
Finest Trinidad nibs	2·60	51·77	45·63	1 to ·8	None.	None.
Cocoa extract (No. 1)	3·52	23·98	72·50	3·0	,,	,,
Chocolatine............	4·40	29·60	66·00	2·2	,,	,,
Cocoa extract (No. 2)	5·76	29·50	64·74	2·1	,,	,,
Flake.....................	5·49	28·24	66·27	2·3	,,	,,
Rock	2·58	22·76	24·90	1·09	17·56	32·20
Prepared	4·95	24·94	27·89	1·1	19·19	23·03
Iceland Moss	5·47	16·86	23·74	1·4	24·70	29·23
Chocolat de Santé	1·44	22·08	13·27	·6	2·00	61·21

Kind.	Per cent. of—		Amount of ash soluble in cold water.
	Ash.	Cocoa soluble in cold water.	
Trinidad nibs	2·86	10·58	2·44
Cocoa extract (No. 1).	6·81	18·00	3·95
Chocolatine	6·14	18 50	4·50
Cocoa extract (No. 2).	5· 4	16·72	4·36
Flake	5·39	18 10	4·00
Rock	1·56	36·70	0·90
Prepared	1·52	31·66	1·17
Iceland Moss	1·83	40·80	1·06
Chocolat de Santé	1·76	65 60	1·26

It will be observed that there are two distinctive variations in composition, viz., the fat and the ash. Some contain much more fat than others, but from the same Table the proportion of ash naturally present in cocoa can be seen, and after making proper allowance for the reduction in the quantity of fat, the quantity of mineral matter which has been added in the process of manufacture for imparting colour and solubility to the extractive can be easily deduced.

Of the different descriptions of commercial cocoa now before the public, it is only just to the manufacturers to say that no kind has during the last few years so advanced in public estimation as this which has been deprived of the greater part of its natural fat and made more soluble by special processes. It is not my duty to direct attention to the production of any special manufacturer, but it is right that I should point out that cocoa so prepared is a very valuable article of diet, and is the best of the many preparations of cocoa submitted to the public. As the nitrogen is increased by the removal of the greater portion of the natural fat, it has become richer as a flesh-former than when in its natural state, and being made more soluble the inconveniences inseparable from ordinary cocoa preparations have been greatly modified. Cocoa does not suit every constitution, but to those who can take it and prefer it to tea or coffee, there is no doubt that the modern preparation now under consideration is of very great value. It has none of the objections of the so-called soluble cocoas, and yet is very soluble and nutritious, being strongly recommended by the medical profession in cases of debility as a partial substitute for tea and coffee.

Those manufacturers who use an alkali to increase the solubility of the cocoa are careful to use such as are wholesome. By this means the solubility is increased considerably, and such a cocoa appears to please the public.

The average ash of raw cocoa is from 2·5 to 3·2 per cent, that of fat-reduced cocoa is from 4 to 5 per cent., and cocoa treated with alkali

TABLE XXXVII.—ASH OF NIBS AND HUSK.

Constituents.	Guayaquil Nibs.	Surinam Nibs.	Grenada Nibs.	Finest Trinidad Nibs.	Finest Trinidad Husk.
Sand	—	—	—	—	5·12
Silica	·15	—	—	—	2·87
Chloride of Sodium ($NaCl$)	·46	·53	·57	·65	·44
Soda (Na_2O)	·46	·63	·57	·83	·94
Potash (K_2O)	23·35	28·00	27·64	29·30	37·89
Magnesia (MgO)	19·18	20·66	19·81	18·23	13·04
Lime (CaO)	3·24	4·38	4·53	6 51	7·30
Alumina (Al_2O_3)	·10	·04	·08	·08	·55
Protoxide of Iron (FeO)	·21	·38	·15	·10	·63
Carbonic Anhydride (CO_2)	·69	3·31	2 92	4·19	10·80
Sulphuric ,, (SO_3)	2 77	4·29	4·53	3·91	3·25
Phosphoric ,, (P_2O_5)	49·39	37·78	39·20	36·20	17·17
	100·00	100 00	100·00	100·00	100·00

gives an ash as high as 8 per cent. The principal constituents of the ash to which alkali has been added are potash and phosphoric acid, two important and valuable mineral substances required for building up the bones and tissues of the body.

The Table XXXVII. shows which of the cocoa extracts or essences have been treated with mineral salts; and by comparing the proportions of ash present we have a ready way of satisfying ourselves of the presence of added alkali.

COCOA: CHEMICAL COMPOSITION.

In chemical composition, cocoa, like coffee, differs from tea, in having a large proportion of natural fat—in this respect standing much above coffee; by reason of this, too, and of a small per-centage of starch, it ranks higher than coffee altogether as a nutritious beverage. It differs, also, from both tea and coffee with regard to astringent constituents: while free from the high proportion of tannin found in tea, it appears to contain an astringent principle in rather larger quantity than that of the caffeic (or chlorogenic) acid in coffee.

The following analyses will convey an idea of the average composition of cocoa:—

TABLE XXXVIII.

Analysis of Raw Trinidad Nibs. (Inland Revenue Laboratory.)		Analysis of Shelled, Fresh Cocoa-beans. (Boussingault.)	
Moisture	5·23	Water	7·6
Fat	50·44	Fat	49·9
Starch	4·20	Starch and starch sugar	2·4
Albuminous matter—		Albumin	10·9
Soluble	6·30		
Insoluble	6·96		
Astringent principle	6·71	Tannin	·2
Gum	2·17	Albumin (gum)	2·4
Cellulose	6·40	Soluble cellulose	10·6
Alkaloids	·84	Theobromine	3·3
Cocoa red	2·20	——	—
Indefinite organic matter (insoluble)	5·80	Undetermined	5·3
Ash	2·75	Ash	4·0
——	—	Tartaric acid	3·4
	100·00		100·0

The fat, or cocoa-butter, which is present in such a remarkably large proportion, constituting half of the weight of the bean, is a yellowish-white, odourless solid, having about the same consistency as tallow. As is seen, however, from the methods of manufacture, this large per-centage is never present in forms of cocoa as sold—either the fat by itself has been partly eliminated by pressure, or the proportion of cocoa as a whole has been reduced by addition of starch, &c.

The analyses of commercial cocoas in the Table preceding, show the average quantity of fat to be about 25 per cent.; all preparations should contain at least 20 per cent.

Starch appears to exist in cocoa to a smaller extent than was formerly supposed. When seen under the microscope, its granules can be distinguished from those of the starches usually added during the manufacture.

There is but a trace of true tannin in cocoa; the astringent portion of the bean is of the same nature, however, but has hitherto been little investigated, owing partly to its want of stability, which makes its estimation rather difficult.

The principal alkaloid of cocoa (theobromine) is not identical with that of tea and coffee, though bearing a close chemical relation to it. Chemists have found somewhat varying quantities of it in their analyses of cocoa; the foregoing Tables give the highest, and one of the lowest, values we have seen—the average seems to be about 1·2 per cent. A Table is given elsewhere, showing some different estimations of this constituent. In the same Table are also shown the quantities in the same samples of a second alkaloid, distinct from theobromine, and which crystallises like theine. It contains less nitrogen than either theobromine or theine—a complete investigation of it, however, has yet to be made.

The ash, or mineral constituents of cocoa, range from 2·3 to 4·5 per cent. Its most noteworthy feature is its great solubility—one half being soluble in water—and the small proportions of soda, carbonates, and chlorides. The estimation of the ash affords a useful method of confirming the presence of foreign matter in preparations of cocoa; on the one hand, as previously mentioned, an abnormally high per-centage of ash is indicative of added mineral salts to increase the solubility of the article—on the other, an unusually low amount of ash serves to show the amount of true cocoa present in commercial mixtures.

The quantity of albuminous matter in cocoa seems constant at 13-14 per cent.—proportions which place cocoa between tea and coffee with respect to this constituent; but a far larger part of the total albumin in cocoa is soluble than is the case with the two rival beverages.

TABLE XXXIX.—PER-CENTAGES OF THEOBROMINE AND THEINE-LIKE ALKALOID.

Cocoa.	Per cent. Theobromine.	Per cent. Theine-like Alkaloid.
Guayaquil	0·54	trace
Grenada	0·91	,,
Surinam	0·78	0·02
Trinidad	0·59	0·25
,, husk........	1·02	0·33

TABLE XL.—PER-CENTAGE OF MOISTURE AND TOTAL ASH WITH THE RELATIVE SOLUBILITY OF ASH.

Kind of Nibs.	Per cent of moisture.	Ash from 100 grains—dry.			
		Soluble in water.	Insoluble in water, but soluble in dilute hydrochloric acid.	Insoluble in dilute hydrochloric acid.	Total.
Guayaquil	5·06	2·04	1·59	none	3·63
Surinam	4·55	1·26	1·64	,,	2·90
Grenada	5·71	1·37	1·45	,,	2·82
Finest Trinidad ...	4·47	1·28	1·47	,,	2·75
,, ,, husk	10·19	4·74	3·38	0·51	8·63

TABLE XLI.—PER-CENTAGE OF ASH SOLUBLE AND INSOLUBLE IN WATER AND DILUTE HYDROCHLORIC ACID.

Name.	Soluble in water.	Insoluble in water, but soluble in dilute hydrochloric acid	Insoluble in dilute hydrochloric acid.
Guayaquil nibs	56·20	43·80	none
Surinam ,, ...	43·45	56·55	,,
Grenada ,, ...	48·58	51·42	,,
Finest Trinidad nibs	46·55	53·45	,,
,, ,, husk	54·92	39·17	5·91

COCOA: ITS PROPERTIES.

When compared with tea and coffee, cocoa is found to be somewhat deficient in those aromatic principles which have an exciting effect on the nerves of taste and smell. The alkaloids of cocoa are equal in amount to the alkaloid found in coffee, but they do not exert an equally stimulating effect upon the central nervous system.

Cocoa is, on the other hand, especially rich in some of the elements of a perfect food, viz., fat, albumin, and starch, and has nearly twice the mineral salts found in tea.

By referring to the various Tables of analyses of commercial cocoa it will be observed to what extent the original constituents of cocoa as existing in the beans have been either removed or supplemented during manufacture in order to adapt the finished article to individual tastes and digestive capacities. These remarks apply especially to the fat. During the process of digestion, fat practically undergoes no change until it has passed the stomach, and becomes mixed with the secretions of the liver and pancreas. During the time cocoa butter remains in the stomach it is liable to give very undesirable evidence of its presence there. Whether this be due to personal idiosyncrasy or to some peculiar physiological action of the cocoa butter cannot be determined with accuracy.

To obviate these unpleasant effects, and to render cocoa more suited to the wants of the masses, a large proportion of fat is frequently removed, as stated elsewhere, during the process of manufacture. The fat which is allowed to remain, and the albuminous and amyloid constituents, undergo the usual changes in the body. It is evident that the quantity of these food stuffs in a cup of cocoa is comparatively insignificant when contrasted with the amount of the same substances derived from other articles of food consumed during an ordinary meal.

When deprived of the excess of fat, cocoa yields a bland, easily digested, and slightly stimulating beverage, generally free from any subsequent unpleasant effects.

It must not be forgotten that cocoa, in one or other of its many commercial forms, is consumed as a food, and sometimes as a condiment; we can scarcely argue dryly whether, when so taken, it is a cheap or a dear food. It is not taken as such, but more as a substitute for sweets by the young; on these lines it is perfectly safe to state that it is an improvement on the use of an inordinate quantity of sugar, and the use of cocoa as "sweets," in the form of chocolate or a chocolate cream, should be encouraged rather than condemned. It nourishes rather than fattens, and though it may be somewhat expensive as an article of diet, it is wholesome, and being easily obtained and stored for use, children consume large quantities of it in place of sugar. The increased consumption of cocoa, to which I shall subsequently refer, is a proof, if proof were needed, of the favour bestowed upon cocoa and its many preparations; and now the British manufacturer is employing skilled talent in improving its preparation, and making what the public appreciate, there will be an increased demand for it, and a likelihood of cocoa taking its proper position amongst the non-intoxicating beverages in common use.

CHOCOLATE: ITS MANUFACTURE.

The chocolate as known to us is in the solid state, and made up into many distinctive forms. In this condition it is largely used as a sweetmeat, and consequently the cocoa used in its preparation must be of the best quality, free from objectionable flavour and bitterness. Unfermented cocoa is very unsuitable, being objectionable both in colour and flavour, but a bean like the fermented Trinidad is eagerly sought after, and consequently commands a high price. The commoner kinds are used in the preparation of chocolate and chocolate creams of low quality, into which large quantities of sugar, farina, and flavouring matter enter, and thus disguise the quality of cocoa used.

The large blocks of cocoa, which have been very finely disintegrated at a high temperature, are thoroughly incorporated with suitable proportions of pure white sugar in a mill specially designed for the purpose. When this has been done, starch and flavouring matter are frequently added, and the mixture is then either made into sticks, cakes, or other forms for consumption.

Good chocolate should turn out from the moulds quite clean and bright; it should not acquire a bloom by keeping, but should remain of a brown chestnut colour even after being long in store. It should melt quickly in the mouth, and leave no roughness or astringency on the tongue. The Spanish, French, and Swiss place cocoa on the market chiefly in the form of chocolate or chocolate creams, whilst the Dutch eat and drink it as cocoa, and the English both as cocoa and chocolate.

These practices have an effect on the consumption of cocoa fat, which is pressed out of the cocoa made to be sold as pure cocoa deprived of a portion of its fat, and which, as before stated, is very extensively manufactured in this country and Holland.

In the manufacture of chocolate for covering the creams it is necessary to introduce an extra quantity of cocoa fat to give covering power and smoothness to the chocolate used. Cocoa butter can therefore be obtained from the cocoa manufacturing countries for this purpose, and Holland notably is a large exporter. Cocoa butter of excellent quality and purity is frequently sold by our cocoa manufacturers for pharmaceutical and other purposes, and in its place they get a darker-coloured butter equally suitable for their requirements, but which is of a lower commercial value. The colour appears to be due to the effects of the high temperature at which the cocoa is pressed, and not to any defect in the butter itself.

The chocolate, when prepared, is either poured over the creams, or the creams are dipped into the chocolate. Frequently the girls who perform this work use their fingers for holding the cream, and, as a rule, the impression of the finger can be traced on every such cream. Others use a wire for the purpose, so that the chocolate on the face of the cream is uniform without depression. The cream is made either by heating powdered loaf sugar till it melts, or a mixture of powdered sugar and glucose. The cream, after a while, granulates into a stiff mass, but is easily soluble, and for making creams is poured in a liquid condition into little moulds which have been made in starch flour. The chocolate is poured over them after they have been moulded, and is frequently spread uniformly by the motion of the table on which the operation is conducted, this motion being imparted by mechanical means, and in different directions, to effect the intended purpose.

Chocolate creams and other fancy preparations of chocolate now manufactured are very numerous, and embrace many descriptions which can be roughly classified for illustration. Thus the cream used is flavoured with different materials, or it may be mixed with fruit extracts for flavouring or for taking away or modifying the sweetness of the sugar.

Extracts of malt, coffee, or tea are sometimes introduced, and in this way the cocoa is made a vehicle for bringing into notice its rivals tea and coffee.

Sometimes, also, burnt almonds and other seeds are used for interior flavouring. The domain of medicine has also been invaded by the enterprising chocolate maker, and we can obtain in the ordinary way of trade pectoral and medicinal chocolates. The number of the different preparations is legion, as will be evident from the fact that on three trade-lists I have studied, one manufacturer enumerates 221 assortments, the second 244, and the third 253.

The increase in cocoa consumption has

during the last few years been considerable, and without taking too sanguine a view, we may expect this increase to steadily progress, on account of the attractive and pleasant forms in which cocoa can be obtained, either as a drink or as a food.

In bringing this series of lectures to a close, it will be of public interest to note how the three non-intoxicating beverages—tea, cocoa, coffee and coffee substitute—fare with the intoxicating drinks, spirits, wine, and beer, as regards their general consumption.

During the thirty-three years ending December, 1888, the quantity of spirits and wine consumed per head of the population increased from 1·26 to 1·29 gallon at proof, and beer from 22·6 to 26·8 gallons per head. Even this comparison shows that the public taste had, during the period referred to, gone in the direction of the weaker and more harmless intoxicant, beer, and this change is encouraging to those who desire to see the people of this country become a more sober nation.

When we turn to the consumption of non-intoxicants, the picture becomes much brighter, for the quantity consumed increased from 3·64 lbs. to 6·58 lbs. per head. This increase has been greatly aided by the facilities now given to obtain tea and coffee at coffee taverns and other good refreshment bars. The accommodation thus given is greatly appreciated by the public, and even the tavern-keeper is following in the same direction by offering his customers the choice of non-intoxicants as well as of intoxicants.

On all sides there is a strong desire to bring down our intoxicating drink bill, and we who live in the metropolis and are compelled to see what is going on amongst the masses, must cordially welcome any change in public opinion and taste which tends to promote sobriety and rational enjoyment, and inclines the bread-winner of the family to seek for home pleasures instead of the temptations and allurements of the tavern, or bogus club, and the baneful associations connected therewith.

TABLE XLII.—COCOA (LBS.).

	IMPORTS.					CONSUMPTION.	
Year.	British Possessions.	Ecuador.	Brazil.	Other Countries.	Total.	Total.	Per Head.
1873..	8,538,327	4,353,908	1,065,585	5,703,427	19,661,247	8,311,023	·26
1874..	6,822,678	6.044,012	563.377	4,423,885	17,853,952	8,863,579	·27
1875..	6,414,065	4,765,790	994,967	3,696,429	15,871,251	9,973,926	·30
1876..	10,425,547	4,578,522	1,917,064	3.461,175	20,382,308	10,428,675	·31
1877..	8,171,088	3,707,976	1,460,925	3,636,453	16,976,442	10,060,637	·30
1878..	10,711,141	1,655,867	2,518,703	3,127,128	18,012,839	9,980,162	·29
1879..	14,139,451	6,281,886	669,209	5,254,215	26,344,761	10,111,526	·29
1880..	11,454,813	6,000,414	554,524	5.531,406	23,541,157	10,566,159	·30
1881..	12,305,313	4,181,158	1,151,804	4,730,253	22,368,528	10,897,795	·31
1882..	12,189,128	3,342,037	859,406	2,599,870	18,990,441	11,996.853	·34
1883..	13,824,208	3,231,961	1,876,248	3,700,277	22,632,694	12,868,170	-36
1884..	15,150,324	3,006,619	1,553,277	2,959.048	22,669,268	13,963,891	·38
1885..	14,608,359	2,548,308	1,625,187	4,637,542	23,419,396	14 595,160	·40
1886..	13,590,164	6,032,874	447,634	5,315,767	25,386,439	15,165,714	·41
1887..	13,548,376	4,565,881	1,711,898	7,633,345	27,459,500	15,873,698	·42
1888..	19,167,230	3,046,653	879,598	6,473,066	29,566,547	18,227,017	·48
1889..					26,735,274	18,464,164	·48

The lines in the chart (p. 1051) representing the population and the consumption of the different articles enumerated on it require careful and attentive study, and will amply repay the student who takes the trouble to learn the lessons the chart teaches.

The line of population is one of steady and fairly regular increase, not marked by any exceptional developments during the thirty-three years to which it relates.

Coffee has had a singular history, and therefore it must be looked upon as having had,

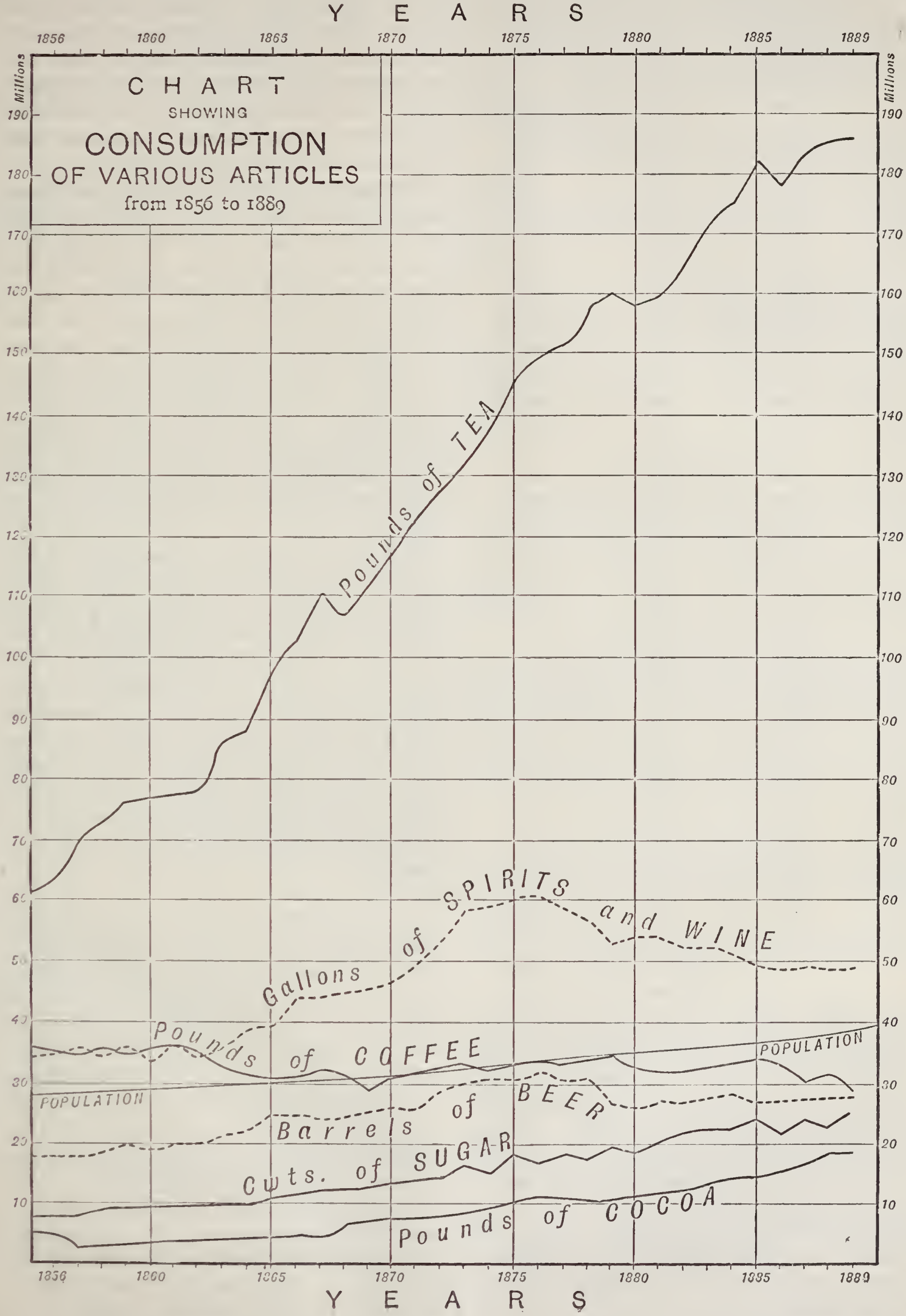
YEARS
1856
1860
1865
1870
1875
1880
1885
1889
Millions
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
CHART
SHOWING
CONSUMPTION
OF VARIOUS ARTICLES
from 1856 to 1889
Pounds of TEA
Gallons of SPIRITS and WINE
Pounds of COFFEE
POPULATION
Barrels of BEER
Cwts. of SUGAR
Pounds of COCOA

TABLE XLIII.—CONSUMPTION PER HEAD.

Year.	Non-intoxicants	Intoxicants.	
	Tea, Coffee, Cocoa, and Chicory.	Spirits and Wine.	Beer.
	lbs.	gallons.	gallons.
1856	3·64	1·26	22·6
1857	3·76	1·26	22·6
1858	3·92	1·20	23·6
1859	3·98	1·25	24·8
1860	4·01	1·16	23·8
1861	4·38	1·23	24·3
1862	4·07	1·16	24·1
1863	4·53	1·20	25·5
1864	4·59	1·29	26·7
1865	4·84	1·34	29·8
1866	4·95	1·45	29·5
1867	5·24	1·44	28·2
1868	4·04	1·48	28·2
1869	5·08	1·46	29·2
1870	5·32	1·50	30·2
1871	5·44	1·57	29·3
1872	5·58	1·67	32·3
1873	5·72	1·79	33·3
1874	5·81	1·79	34·1
1875	6·05	1·82	33·4
1876	6·13	1·83	33·8
1877	6·10	1·74	32·4
1878	6·24	1·67	32·2
1879	6·32	1·54	27·9
1880	6·17	1·54	27·0
1881	6·13	1·52	28·2
1882	6·22	1·48	27·1
1883	6·38	1·46	27·5
1884	6·41	1·42	27·5
1885	6·64	1·35	26·4
1886	6·45	1·32	26·9
1887	6·50	1·32	26·9
1888	6·58	1·29	26·8

from special causes, a career very different from its competitors. The fluctuation in consumption has been very great, but the tendency has always been downwards, till during the last three years the falling off has been most marked. Why this has been the case has been shown in the second lecture, and it seems as if there were no hope that this article, though particularly wholesome, will ever advance in public favour as a national beverage, on account of the difficulty and cost of its preparation.

Through the efforts made to prepare cocoa as a food as well as a drink, the consumption has greatly increased, for it has been seen that by taking out portions of the natural fat, or by adding starch in one form or another, to absorb it, the natural difficulties of using cocoa have been modified or overcome. Again, in chocolate and chocolate creams the public have a nutritious food as well as a sweetmeat, and many a toiler or holiday seeker has been braced up to continued endurance by eating a few creams or other cocoa preparations.

The most marked development in consumption has taken place in tea. It has increased by leaps and bounds, and the probability is that if India and Ceylon teas, which are stronger than China growths, had not so largely increased in consumption, the chart line would have shown still greater progress. It will be seen that the prosperous years of 1870-75 had no effect in diminishing the consumption of tea and cocoa, and this fact must be taken as proving that tea and cocoa are ranked amongst life's necessaries, and used as regular articles of diet in the family.

Beer and spirits seem to keep pace in consumption, at any rate within certain limits, with the wage-earning power of the working classes, and as soon as wages fall the consumption of beer and spirits falls also. It is apparent from such facts that the working classes are the large consumers of intoxicants, and the elevation of the lines on the chart representing alcoholic drinks reads a silent lesson on the large amount of money uselessly spent in strong drink, which would have been better employed in the purchase of home comforts, or as an investment for sickness or old age.

As before stated, there is an improvement in the habits of the nation as regards sobriety, but, at the same time, the rate of progress is very slow, and disheartens many who are vain enough to expect that nations can become changed in their habits without difficulty, and can turn from drunkenness to sobriety apparently without any effort. Such a rapid change cannot take place, but the past is bright with promise, and if rational recreation, wholesome food, and non-intoxicating, inviting drinks can be provided for the masses, drunkenness will receive a rude and a permanent shock, and as the surroundings of our wage-earning population are improved we may confidently expect a corresponding improvement in their habits, and a more marked preference shown for non-alcoholic as against intoxicating drinks.

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FRIDAY, NOVEMBER 14, 1890.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

NOTICES.

ARRANGEMENTS FOR THE SESSION.

The First Meeting of the One Hundred and Thirty-seventh Session of the Society will be held on Wednesday, the 19th November, when the Opening Address will be delivered by the ATTORNEY-GENERAL, M.P., Chairman of the Council. Previous to Christmas, there will be four Ordinary Meetings, in addition to the Opening Meeting. The following arrangements have been made:—

ORDINARY MEETINGS.

NOVEMBER 19.—Opening Address by the ATTORNEY-GENERAL, M.P., Chairman of the Council.

NOVEMBER 26.—FRANCIS GALTON, F.R.S., "Physical Tests in Competitive Examinations." SIR WILLIAM S. SAVORY, Bart., F.R.S., will preside.

DECEMBER 3.—JAMES DREDGE, "The Chicago Exhibition, 1893." The ATTORNEY-GENERAL, M.P., Chairman of Council, will preside.

DECEMBER 10.—F. BAILEY, "Electric Lighting Progress in London." SIR FREDERICK BRAMWELL, Bart., D.C.L., F.R.S., will preside.

DECEMBER 17.—GEORGE DAVISON, "Impressionism in Photography."

Papers for which no dates have as yet been fixed:—

"Methods and Processes of the Ordnance Survey." By COLONEL SIR CHARLES WILSON, K.C.B., K.C.M.G., F.R.S.

"Lands available for Colonisation." By E. J. RAVENSTEIN.

"Fast and Fugitive Dyes." By PROF. J. J. HUMMEL.

"Photography in Aniline Colours." By A. G. GREEN, C. F. CROSS, and E. J. BEVAN.

"The Use of Petroleum in Prime Motors." By WILLIAM ROBINSON.

"Illustrated Journalism." By CARMICHAEL THOMAS.

"The Growing Need for Decimal Coinage, Weights, and Measures." By T. EMERSON DOWSON.

"Sgraffito." By HEYWOOD SUMNER.

"Glass Painting." By H. ARTHUR KENNEDY.

"Electricity in relation to the Human Body." By H. NEWMAN LAWRENCE and ARTHUR HARRIES, M.D.

"Steam Lifeboats." By J. F. GREEN.

"The Sources of Petroleum." By WM. TOPLEY, F.R.S.

"The Proposed Irish Channel Tunnel." By SIR ROPER LETHBRIDGE, M.P.

FOREIGN AND COLONIAL SECTION.

The meetings of this Section will take place on the following Tuesday afternoons, at Half-past Four o'clock:—

January 20; February 17; March 17; April 21; May 5, 26.

INDIAN SECTION.

The meetings of this Section will take place on the following Thursday afternoons, at Half-past Four o'clock:—

January 22; February 26; March 12; April 9, 30; May 28.

APPLIED ART SECTION.

The meetings of this Section will take place on the following Tuesday evenings, at Eight o'clock:—

January 27; February 10; March 10, 24; April 14; May 12.

CANTOR LECTURES.

The following Courses of Cantor Lectures will be delivered on Monday evenings at Eight o'clock:—

Prof. VIVIAN B. LEWES, "Gaseous Illuminants." Five lectures.
November 25; December 1, 8, 15, 22.

A. J. HIPKINS, F.S.A., "The Construction and Capabilities of Musical Instruments." Three lectures.
January 26; February 2, 9.

GISBERT KAPP, "The Electric Transmission of Power." Three lectures.
February 16, 23; March 2.

Prof. R. MELDOLA, F.R.S., "Photographic Chemistry." Three lectures.
March 9, 16, 23.

HUGH STANNUS, F.R.I.B.A., "The Decorative Treatment of Natural Foliage." Four lectures.
April 13, 20, 27; May 4.

JUVENILE LECTURES.

Two Lectures, suitable for a juvenile audience, will be delivered by E. B. POULTON, M.A., on "Mimicry in Animals," on Wednesday evenings, December 31, 1890, and January 7, 1891, at Seven o'clock.

Miscellaneous.

AMBROSE GODFREY.

MAKER OF PHOSPHORUS AND INVENTOR OF A FIRE ANNIHILATOR.

The laboratory in which the first ounce of solid phosphorus was prepared in England was standing in Maiden-lane, Covent-garden, until a few years ago, when a Roman Catholic Church was erected on the site. Ambrose Gottfried Hanckewitz, a German, who settled in England. and adopted the name of Ambrose Godfrey (except in formal documents, where his name always appeared as Ambrose Godfrey Hanckewitz), was employed by the Hon. Robert Boyle, who was induced by the discovery of phosphorus in 1669 by Brandt, an alchemist of Hamburg, to make experiments on this substance. Godfrey, who was the founder of the house afterwards and still known as Messrs. Godfrey and Cooke, opened a laboratory at the back of his house in Southampton-street, and there he succeeded in obtaining an ounce of solid phosphorus. This laboratory had an entrance in Maiden-lane, and opened into a garden which extended as far as the Strand. It became a fashionable resort, and popular experiments were frequently performed here. Prints of the laboratory still exist, and also a portrait of Ambrose Godfrey, painted by R. Schmutz, was engraved by G. Vertue in 1718.

Robert Boyle deposited with the Royal Society, in 1680, a sealed account of his method of obtaining phosphorus, which was printed in the *Philosophical Transactions* after his death (vol. xvii., p. 583), but he had previously (in 1682) published himself an account which will be found in his *Works*. He describes Godfrey as "a learned and ingenious stranger, who had newly made an excursion into England to see the country;" and adds, "Having, in a visit he was pleased to make me, occasionally discoursed, amongst other things, about the German *Noctiluca*, whereof he soon perceiv'd I knew the true matter, and had wrought much upon it." (*Works*, iv. 383.) Ambrose Godfrey, in a pamphlet on his invention for extinguishing fires, published in 1724, speaks of his forty years' experiments and "operations and essays relating to the production and actions of fire, and of heat and cold in their several degrees." All these, he adds, "contributed towards my better perfecting that wonderful preparation, the *Phosphorus Glacialis*, of which, since the death of one Mr. Bilger, I may call myself, for near these forty years, the sole maker in Europe; for on the strictest enquiry I could never hear of anybody either at home or abroad, nor have I met in my travels with any person that did prepare the solid and transparent phosphorus besides myself. Some indeed have obtained a few grains, but none could as yet produce the quantity of 7 or 8 ounces in one distillation, except myself; and though this preparation is of my own finding out, yet here I confess, with the utmost sense of gratitude, that I am indebted for the first hints of the matter whence it is made, to that ornament of the English nation, the great Mr. Boyle, my kind master and the generous promoter of my fortune, whose memory shall ever be dear to me." Godfrey was elected a Fellow of the Royal Society on January 22, 1729-30, and he contributed two papers to the *Philosophical Transactions*, viz., "An Account of some Experiments upon the Phosphorus Urinæ" (vol xxxviii,, pp. 58-70), and "An Examination of the Westashton Well Waters" (vol. xli., part 2, pp. 828-30).

In 1723 Godfrey brought to perfection his invention for extinguishing fires, and in his patent, which is dated 12th Nov., 1723, it is described as "consisting of divers casks and other vessels and materials for the extinguishing of fires in houses and ships, of which he hath made two publick experiments with good success." The first of these experiments was tried in the presence of the Lord Chancellor, Sir Hans Sloane, Sir George Beaumont, Sir J. Thornhill, and other distinguished persons, in Belsize-park on the 2nd of April, 1723. "A wooden house, three stories high, having been erected for the purpose, with the addition of shavings, brushes, faggots, pitch, oil, &c., to increase the fury of the flames, which were suffered to rise to their utmost height. Then a machine was flung into the ground apartment, which instantly extinguished the fire there."

The second experiment was tried in Westminster-fields on May 30th, when a fire lighted in a house of three storeys was extinguished in three minutes. These experiments were described in a pamphlet published in 1724, entitled "An Account of the New Method of Extinguishing Fires by Explosion and Suffocation," in which Godfrey complains of Charles Povey's behaviour to him, Povey being the proprietor of Belsize-house and a rival inventor. On the title-page is this reference to the patent taken taken out in the previous year:—"A method easily practicable, certain in its effects, and so universally useful to the publick, that his Majesty has been moved to authorize and encourage this happy discovery, for the general advantage of his subjects, by his most gracious Letters Patent."

The following description of the apparatus is given by the inventor:—"The new method I have to offer to the publick consists of gunpowder closely confined, which as soon as animated by fire acts by its elastic force upon a proper medium [water impregnated with a certain preparation] and divideth it instantly into millions of millions of most minute and imperceptible atoms, which with equal violence and swiftness are immediately forced into the innermost recesses of the flames." Further on we are told that "The constituent parts of the machines are the shell and the powder magazine. The shell is a small wooden barrel with wooden hoops: in the middle of the top an opening is left for the fuzee to pass through. This barrel is cased without and well lined within, the better to hold the liquid: which is a mixture which never corrupts or alters, when on the contrary mere water would soon putrify and stink. The powder magazine is a vesica of a spheroidal figure, either of pewter or some other lasting substance, filled with gunpowder, having on one end a pipe, which pierces the top of the shell in the middle, and serves to guide the fuzee to the main magazine. This powder magazine is fixed in the centre of the shell, incompassed with the above-mentioned liquid. The fuzee is garnished with wild-fire, secured with a tin cover lined, to be taken off when the machine is to be used."

The prices of the machines were—first size, £1 5s.; second size, £1 1s.; third size, 18s. The chimney shells—first size, 10s. 6d.; second size, 7s. 6d. They were sold at "Mr. William Brigges', joiner, over against Salisbury-street, in the Strand."

These small kegs appear to have been used for a time with success, as the following notice from *Bradley's Weekly Messenger* of November 7, 1727, seems to show:—"Last Sunday . . . a fire broke out at the 'Crown Tavern,' in King-street, near Guildhall. The same morning, I am informed, two other fires occurred, but I have not heard the particulars. In some of these, however, I hear that the famous machines, or fire watches, invented by Mr. Godfrey, the great chymist, in Southampton-street, Covent-garden, display'd their wonderful effects, and prevented the progress of that furious element; with what quiet and satisfaction may we not therefore live when we have the advantage of such safeguards."

The inventor died on 15th January, 1741, and his pamphlet was reprinted in 1743 and 1744; but little more is heard of the fire annihilator until September, 1760, when the inventor's son, Ambrose Godfrey (the second), wrote to the Society of Arts, "giving an account of the success of his family's invention for the extinguishing of fires." This letter was considered by a committee, and arrangements were made for testing the invention. A Mr. Keys was engaged to erect a building in the Marylebone-fields which could be experimented upon. The date and hour were fixed, but great fears were entertained in respect to the conduct of the mob that was likely to be attracted to the exhibition. The secretary was "ordered to write to the printers of the several newspapers printed and circulated within the Bills of Mortality, that it is the request of the Society that if they should hear of the day appointed for the experiment for extinguishing fires, they will not insert the day in their papers." Application was made to the authorities for a guard of 200 men, and a civil magistrate was requested to attend. The experiment was successful, and gratuities were given to the guard and to the peace officers. The cost of building the house was £54 1s.

The following description of the proceeding is taken from a contemporary number of the *Gentleman's Magazine* (vol. xxxi., p. 236):—"May 19, 1761, Mr. Godfrey's experiment for extinguishing fire was tried in the house erected for the purpose, by the Society of Arts, &c., in Marybone-fields. The Duke of York, Prince William and Prince Henry, several persons of distinction, and a numerous crowd attended on this occasion. The house, which is of brick, consists of three rooms, one above another, a staircase, chimney, lath and plaster ceilings, and a kind of wainscoting round the rooms, of rough deal. At twelve o'clock the ground room and that up one pair of stairs were set on fire by lighting faggots and shavings laid there for that purpose. In about fifteen minutes three of the machines were thrown into the under room (the wainscot of which was then in flames), which by their explosion immediately extinguished the fire, and even the smoke soon disappeared. The like experiment was next tried with the same success on the middle room, the staircase by that time having taken fire, and lastly, to remove all doubt (the populace beginning to be dissatisfied, and to talk of a second bottle conjuror), Mr. Godfrey consented to a third experiment in the upper room, which was entirely of wood. The flames were now suffered to get to a considerable height, and even the window frames destroyed before the machines were thrown in, which, however, answered exactly as before. One hundred and forty of the Foot Guards attended on this occasion."

Ambrose Godfrey (the first) named one of his sons after his great patron, Boyle; but Boyle Godfrey, who obtained a foreign degree of M.D., appears to have been unsuccessful in life, partly caused by the prosecution of costly experiments in the pursuit of alchemy. He published, in 1735, a work entitled "Miscellanea Vere Utilia, or Miscellaneous Experiments and Observations on Various Subjects;" a second edition of which was published in 1737, "Printed for J. Robinson, near the Bedford Tavern, in Tavistock-street, Covent-garden, and to be had at the Dispensary near the same place."

A curious epitaph on Boyle Godfrey was written by Dr. Charles Smith, author of the histories of Cork and Waterford. It was read at a meeting of the Dublin Medico-Philosophical Society, on July 1, 1756, and inserted in the minutes of the Society. The epitaph commences thus:—

EPITAPHIUM CHEMICUM.

Here lieth to digest, macerate, and amalgamate with clay
In Balneo Arenæ
Stratum super stratum
The Residuum, Terra Damnata and Caput Mortuum,
of BOYLE GODFREY, Chimist,
and M.D.,

a man who in this earthly laboratory
Pursued various processes to obtain
Arcanum Vitæ
or the Secret to live;
also Aurum Vitæ
or the art of getting, rather than making, Gold.
Alchemist like,
All his labour and propition,
As Mercury in the fire, evaporated in fumo,
When he dissolved to his first principles.
He departed as poor
As the last drops of an alembic;
For riches are not poured
on the adepts of the world.*

Two sons, Ambrose the second, and John Godfrey, carried on their father's laboratory in Southampton-street, and subsequently Ambrose took into partnership his nephew Ambrose, son of Boyle Godfrey already mentioned.

Ambrose (2) and John Godfrey published, in 1747, "A Curious Research into the Elements of Water," which is said to consist of the "conjunctive trials" of the two brothers from their late father's observations.

The partnership of the firm of Godfrey and Cooke was created in 1797, under the will of the third Ambrose Godfrey. Messrs. Godfrey and Cooke left No. 31, Southampton-street about the year 1862, when Mr. Dart, a member of the Society, who had been in their employment, continued the chemists' business next door, at the corner of Maiden-lane.

There are lives of the Godfreys in the "Dictionary of National Biography," and there is an article on the elder Godfrey's invention for putting out fires in *Notes and Queries* (7th s., vol. viii., p. 257).

MINING IN SOUTH AUSTRALIA.

The colony of South Australia has not yet a "Department of Mines." In January, 1889, an inspector of mines was appointed, and a great deal of work has been done which it is expected will make the eventual organisation of a mining department a natural sequence, and then there will doubtless be an annual report such as is prepared in New South Wales (see *Journal*, No. 1,977). There has, however, been recently issued a "Record of the Mines of South Australia," prepared, under the authority of the Hon. the Commissioner of Crown Lands and Immigration, by Mr. H. Y. L. Brown, F.G.S., the Government Geologist.† It is an octavo of 139 pages, with six pages of introductory matter and a sketch map, which does not embrace the northern territory, since the record refers almost exclusively to the south territory, for the northern territory, of which so little is known, occupies but ten pages of the whole.

The work is exactly what its title implies, and under each of the eight headings—copper, silver-lead, bismuth, cobalt and nickel, gold, manganese, iron, coal (brown), and lignite—the mines are arranged in the alphabetical order of their names. Each record gives the position of the mine, generally the date of opening, the geological character of the surroundings, very often the mechanical methods adopted in mining, the output, cost of working, and, where examined, the opinion of the geologist, the inspector, or of experts as to the prospects for the future. Abandoned mines are included, which are numerous, and not unfrequently the only entry is "no record," while in other cases the information is lengthy. To collect facts from so large a district (over 900,000 square miles), without Government organisation for the purpose, is obviously a great undertaking.

In the preface thanks are expressed to mine managers, secretaries, &c., but it is added:—"It is to be regretted that the information supplied in respect of many of the undertakings is only meagre, a circumstance due not to the lack of effort, but to apathy in response on the part of those to whom application has been made."

Although thus not a complete record, the scattered information, of which no tabulation has been attempted, is very considerable.

South Australia was proclaimed a colony in 1836, and the history of mining is taken to date from the opening of Kapunda Copper Mine in 1842. All previous attempts in mining were abortive. From 1845 to the end of 1889 the value of the exports of minerals has exceeded £20,000,000 sterling. Judged by the value of the exports, which does not give the amounts raised, the following figures afford a clue to the relative importance of the mines:—

	£	£
Copper	212,933	13,348,400
,, ore	82,355	6,129,151
Gold	37,305	214,476
Regulus	5,339	125,545
Manganese	5,107	28,615
Lead	2,942	55,414
,, ore	2,332	155,426
Silver	490	862

The first column gives the returns for 1889, the second the grand totals from 1844. They are tabulated here for convenience of reference, though not so tabulated in the "Record."

Of the copper mines there are about 370 enumerated. Some were little more than "prospecting ventures;" some were worked for a while, and abandoned, either for want of capital or from the lode being "lost" in extended workings; and it is intimated that, though in some instances this was the natural result of working out very restricted local patches, it frequently resulted from very imperfect geological knowledge. The greatest drawbacks to success have been want of road communication and want of water, but both of these difficulties are being gradually overcome, the water now being obtained from artesian wells. While lack of water has been a difficulty generally, in some cases mines have been suddenly flooded, and so stopped. A large number of sites are recorded where good lodes have been found, but not yet worked at all, and some of these the inspector has reported on as very valuable. Among the unsuccessful attempts the more important are the Charlton mine, where £20,000 was expended without any return. The New Devon mine absorbed a nominal capital of £28,000, and a second company's capital of £50,000, and after this no further operations were carried on.

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* The whole epitaph is printed in *Notes and Queries*, 5th s., vol. xi, p. 213.

† Adelaide: Printed by H. F. Leader, Government printer, North-terrace. 1890.

It appears there has been considerable want of judgment in adapting systems to localities, *e.g.*, it is stated that at the Curramulka mine there were no indications to warrant the sinking of a shaft, while in other cases shafts were sunk in places obviously wrong to a geologist. Prior to 1882 the colony had no Government geologist, and those who took to mining had to rely on any one they could find of any kind of experience. The extension of intelligent mining is looked forward to hopefully.

In some of the copper mines worked the per-centage of copper per ton of ore is high. There are many recorded above 20 per cent.: Adelaide, 22½; Blinman, 23 to 40; Kirwan, 30; Moonta, 20 to 30 (chalcopyrite), and 30 to 50 (bornite); Billeroo, 28 to 75; Angaston, 33; Burrawing, 37; Currency, 37; Mutooroo, 40; Mount Mary, 41; Nilpena, 62; Moorowie, 64; and Vesey's, 70. The Stanley mine has four distinct lodes, and the Wallaroo five, which range up to 12 or 14 ft. in width. The majority of the workings have not gone beyond 20 to 30 fathoms, though some are deeper, and at the Wallaroo a shaft has been sunk 195 fathoms. Some of the mines the Inspector has visited are spoken of as undoubtedly rich, but cramped in development for want of capital. Blinman is peculiar in being worked rather as a quarry than a mine.

Of silver-lead mines some 170 are enumerated. Here, as in the records of the copper mines, there are numerous entries, "Very little work done," "No records," and in some cases "No ore found." The Inspector of Mines has pointed out that several mines are worth more energetic working, while several he recommends should be abandoned. Some are not worth attempting to work, and some lodes, good enough in themselves, are so circumstanced it would not pay to follow them out. In some cases much money has been spent in sinking shafts where the Inspector reports there were no indications to warrant such an expense.

The per-centages of silver and lead in different ores vary through a wide range. At the Alcare mine, for the first 30 feet in depth, the average has been 50 per cent. lead and silver, 90 oz. to the ton, and from 30 feet to 114 feet little lead, but the silver from 60 oz. to 302 oz. per ton.

At Ediacara, hand-jigging gives 56 per cent. lead and 26 oz. silver. Other figures are 62 and 48, 47 and 10, 32 and 63, 46 and 88; but the majority are below this. In some instances gold has been found associated to the extent of 1 oz. per ton and upwards.*

Of bismuth mines only two are recorded. In one a lode more than 9 feet wide yields from 19 to 60 per cent., with 20 per cent. copper. The other runs from 18 to 79 and 10 to 20 copper. The ore is worth about £44 per ton. Of cobalt and nickel mines, six are mentioned.

There are some 270 gold mines named, but this gives no actual clue to the number of workings, as in some cases one name covers many workings, while in others there is but one. Some of them are isolated, while most lie in groups; the "fields" in each of which are numerous mines. Some of the mines including several workings are Barossa, Echunga, Gumaracha, Manuahill, Oulnina, Parra Wirra, Putt's well, Talunga, Teetulpa, Ulooloo, and Woodside. It is in this last some of the most important mines are situated. Many of the claims taken up were not payable, but there are references to want of systematic mining and to defective crushing, which seems to indicate that want of success was not always due to poorness in the reef.

The list includes alluvial workings as well as mines. In hardly any cases are returns given, but reference is made to the "reticence of the miners and owners of property." The following extract relating to the Barossa reefs gives some idea of the general desultory and unskilful manner of working:—"A good deal of work has been done on these reefs, though with little success. In some instances this has been due to want of system; in others, where the prospects were good, the enterprise has been abandoned for some unknown reason; and in other instances again, payable shoots of gold have been left, and *vertical* shafts have been sunk, striking the reef in a *barren* part." Whatever payable gold there may be in the district, it is so far mostly not yet worked. There have been many "rushes" where the finding of gold has been announced, but the amount of steady, persevering work done has been relatively small.

Eight manganese mines are mentioned, but there are no details. The principal of the three iron mines mentioned has but a capital of £3,000, which is spoken of as far too small for the proper working of the mine.

In the notes on the northern territory it is mentioned that the labour at the mines is done by Chinese at 6s. per day for dry work, and 7s. for wet. They are highly spoken of. The Union gold district appears as the most important yet known, the crushings giving 60, 70, and 80 ozs. per ton of ore. Many tin mines are enumerated. The Union prospector's claim is spoken of as very rich and paying, though the stamp-battery wastes 50 per cent. of the gold. This fact, astonishing as it may seem, is given as well vouched for. The want of improved crushing plant is more than once referred to. Notwithstanding the many drawbacks, the known amount of gold raised up to the end of 1889 was £549,103. Under the head "Gems," 24 companies are mentioned, garnets being the chief object of search.

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* In South African gold mining 1 oz. to the ton is found payable, and is considered not a bad average.

Among all the different drawbacks to mining development mentioned, want of geological and practical mining knowledge are most frequently referred to.

PRODUCTION OF KIRSCHWASSER IN SWITZERLAND.

The production of kirschwasser in Switzerland is carried on in the cantons that produce the best cherries, namely, Basle-Campagne, Bern, Aagau, Freyburg, Grisons, St. Gall, Lucerne, Upper Unterwalden, Soleure, Schwytz, Valais, Vaud, Zug, and Zurich, that is to say, in fourteen cantons out of twenty-two. The United States Consul at Lucerne say that the principal distilleries are in the following cantons—Basle, Lucerne, Schwytz, and Zug. The others are small concerns, consisting of one, two, or at most three, stills. The manufacture of kirschwasser is also carried on to a great extent by the farmers. For the distillation of kirschwasser both black and red cherries are used, but the former are preferable, as producing a spirit of finer quality, and in greater quantity. There are no special methods of cultivation, the cherry trees being generally in the same orchards with apple and pear trees; but as this is the first fruit on which the farmers can realise money they naturally pay great attention to their cherry trees. The process of manufacture is as follows. The cherries are first carefully cleansed, great importance being attached to this point; the stems are then removed, and the fruit packed in very thick wooden casks and left to ferment for a period of from five to eight weeks, according to the weather, after which it is ready for distillation. In large distilleries the stills contain from ten to twelve hectolitres (hectolitre = 22 gals.), while in the smaller ones the quantity varies from these figures to half a hectolitre. The large distilleries, with one or two exceptions, make use of indirect steam as a means of heating, the stills being constructed with double bottoms, through which steam passes. The others employ naked fires, the fuel consisting of peat or the refuse of cherries and pears after distillation, which is compressed into bricks and dried. Both methods of heating have numerous advocates, who each claim the superiority of their system. Kirschwasser is placed on the market in litre (1·76 pints) bottles, in carboys containing from 10 to 60 litres, and in casks. The wholesale market value of kirschwasser varies very much, according to good or bad crops, and consequently according to the price of fruit in good seasons, the price of new pure kirschwasser being sometimes as low as two francs per litre, while in bad seasons it is sometimes as high as four francs, the average being about three francs. All distilleries, it is said, even the best with one exception, adulterate their kirschwasser by the addition of cheap spirit of wine or spirit of potatoes—which is imported from Germany—according to the price offered by the buyer, the cheaper qualities consisting of about three parts of spirit to one part of kirschwasser. All distillers guarantee the purity if the full market price is paid. It is impossible to state with any accuracy what is the annual production. Different statements put down the average at from 300,000 to 500,000 quintals (quintal = 1·9 cwts.). The principal markets for kirschwasser are North America, South America, and British India. France also imports a considerable proportion of Swiss kirschwasser.

Obituary.

A. J. Ellis, Litt. D., F.R.S.—Dr. Ellis, the distinguished phonologist, who died at his residence in West Kensington on Monday night, Oct. 28, was an active member of the Society of Arts since his election in, 1870. The first paper he read before the Society was "A Practical Method of Meeting the Spelling Difficulty in School and in Life" (April 20, 1870), in which he explained the principles of his system of representing spoken sounds, styled by him "glossic." On May 23, 1877, he read a paper "On the Measurement and Settlement of Musical Pitch;" and another on March 3, 1880, "On the History of Musical Pitch." For each of these papers, which contain a complete discussion of the whole subject, the Society's silver medal was awarded to Mr. Ellis. In 1885 he read an important paper "On the Musical Scales of Various Nations," for which also he received the Society's silver medal, and he also made other communications of value to the *Journal*. Mr. Ellis was born June 14, 1814, and educated at Shrewsbury, Eton, and Trinity College, Cambridge, of which college he was elected a scholar in 1835. He graduated B.A. in 1837 as sixth wrangler and first in the second class in classics. In the present year he was admitted to the honorary degree of Litt.D. In early life he entered into the study of phonetics with great ardour, and was proprietor, editor, and chief writer of the *Phonetic Journal*, 1848, and the *Phonetic News*, 1849, and the study of the subject was continued by him throughout his life. He was President of the Philological

Society, 1872-74, and 1880-82, and a paper which he read before that Society on the Pronunciation of the English Language grew into a most exhaustive treatise on the subject, entitled "Early English Pronunciation, with especial reference to Chaucer and Shakespere." He was elected a Fellow of the Royal Society in 1864, and he read several papers on music, logic, "geometrical meaning of imaginaries," "stigmatics," "barometric hypsometry," &c., before that Society, which were printed in the proceedings. In 1875, Mr. Ellis produced a translation of Helmholtz's "Sensations of Tone," a second edition of which (with new notes and appendix) was published in 1885. Although Dr. Ellis's life-long researches were chiefly devoted to linguistics, mathematics, and music, his knowledge on other subjects was deep and wide, and his whole life was one of intense application to work, only interrupted by illness caused by overwork.

General Notes.

Copper.—The production of fine copper from British ores has been gradually decreasing in the last quarter of a century, having fallen from 11,000 tons, in 1866, to 1,456 tons, in 1888; hence we are chiefly dependent on foreign supplies for our manufactures. Last year we imported, in the shape of ore, regulus and precipitate, unwrought metal, in bars, blocks, or ingots, and old copper, &c., of this metal to the value of £6,500,000. The progressive imports are shown to have been as follows:—

	1880.	1885.	1889.
	tons.	tons.	tons.
Ore and regulus........	145,475	189,573	250,567
Wrought and unwrought	39,740	43,997	41,342

Against these imports we exported of British:—

	1880.	1885.	1889.
	tons.	tons.	tons.
Unwrought............	1,547	18,765	32,523
Manufactures, &c......	33,511	41,994	30,788
Foreign wrought or unwrought	14,895	6,449	14,557

MEETINGS FOR THE ENSUING WEEK.

Monday, Nov. 17...British Architects, 9, Conduit-street W., 8 p.m.
Medical, 11, Chandos-street, W., 8½ p m.
Asiatic, 22, Albemarle-street, W., 4 p.m.
London Institution, Finsbury-circus, E.C., 5 p.m. Sir Robert S. Ball, "An Astronomer's Thoughts about Krakatoa."

Tuesday, Nov. 18...Civil Engineers, 25, Great George-street, S.W., 8 p m. 1. Discussion on Mr. John McLaren's paper, "Steam on Common Roads" 2. Professor John Milne and Mr. John McDonald, "The Vibratory Movements of Locomotives."
Statistical, School of Mines, Jermyn-street, S.W., 7¾ p m.
Pathological, 20, Hanover-square, W., 8½ p m.
Sanitary Institute, 74 A, Margaret-street, W. 8 p.m. Mr. A. Wynter Blyth, "Diseases of Animals in relation to Meat Supply; Characteristics of Vegetables, Fish, &c., unfit for food."
Zoological, 3, Hanover-square, W. 8½ p.m. 1. Mr. G. A. Boulenger, "A Catalogue of the Reptiles and Batrachians of Barbary (Morocco, Algeria, Tunisia), based chiefly upon the Notes and Collections made in 1880-84 by M. Fernand Lataste." 2. Mr. G. A. Boulenger, "Remarks on the Chinese Aligator." 3. Rev. O. P. Cambridge, "Some New Species and Two new Genera of Araneidea." 4. Mr. A. Smith Woodward, "Some Upper Cretaceous Fishes of the Family Aspidorhynchidæ."

Wednesday, Nov. 19...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Opening Meeting of the 137th Session. Address by the Chairman of Council.
Meteorological, 25, Great George-street, S.W., 7 p.m. Address by the President, Mr. Baldwin Latham, "The Relation of Ground Water to Disease."
Microscopical, 20, Hanover-square, W., 8 p.m. 1. Mr. A. T. Watson, "The Tube-building Habits of *Terebella littoralis*." 2. Surg. V. Gunson Thorpe, "Note on a New Marine Annelid." 3. Adjourned Special General Meeting—Alteration of Bye-laws.
Archæological Association, 32, Sackville-street, W., 8 p.m.
North-East Coast Institution of Engineers and Shipbuilders, Newcastle-on-Tyne, 7¾ p.m. Address to the Graduates Section by Mr. Frank T. Marshall, President.

Thursday, Nov. 20...Royal Burlington-house, W., 4½ p.m.
Linnean, Burlington-house, W., 8 p.m. 1. Prof. Thos. Johnson, "A Brown Sea-weed—'Punctaria Grev.'" 2. A. Vaughan Jennings, "A Variety of Alectona Millari Carter."
Chemical, Burlington-house, 8 p.m. 1. Messrs. C. O. Sullivan and J. W. Tompson, "The Estimation of Cane Sugar." 2. Prof. S. Young, "A new method of determining the Specific Volumes of Liquids and of their Saturated Vapours." 3. Messrs. Haycock and Neville, "The Molecular Weights of Metals when in Solution."
London Institution, Finsbury-circus, E.C., 6 p.m. Sir John Stainer, "Carols, English and Foreign."
Historical, 11, Chandos-street, W., 8½ p.m.
Numismatic, 22, Albemarle-street, W., 7 p.m.

Friday, Nov. 21...Sanitary Institute, 74A, Margaret-street, W., 8 p.m. Mr. A. Wynter Blyth, "Sanitary Law, English, Scotch, and Irish; General Enactments; Public Health Act, 1875; Model Bye-laws, &c."
North-East Coast Institution of Engineers and Shipbuilders, Literary Society, Sunderland, 7.40 p.m. Mr. W. R. Cummins, "Quadruple Expansion and Increased Piston Speed."
Quekett Microscopical Club, 20, Hanover-square, W.C., 8 p.m.

Saturday, Nov. 22...Botanic, Inner Circle, Regent's-park, N.W., 3¾ p.m.

CONTRIBUTIONS TO THE READING-ROOM.

The Council beg leave to acknowledge, with thanks to the Proprietors, the regular receipt of the following Transactions of Societies and Periodicals.

TRANSACTIONS, &c.

American Academy of Arts and Sciences, Proceedings and Memoirs.
American Chemical Society, Journal.
American Institute of Electrical Engineers, Transactions.
American Philosophical Society, Proceedings.
American Society of Civil Engineers, Transactions.
Association of Engineering Societies, Journal.
Bath and West of England Society, Journal.
Berlin, Polytechnische Gesellschaft, Polytechnisches Centralblatt.
Birmingham Philosophical Society, Proceedings.
British Association for the Advancement of Science, Report.
British Guiana, Royal Agricultural and Commercial Society of, Journal.
British Horological Institute, Horological Journal.
Camera Club, Journal.
Canada, Royal Society of, Proceedings and Transactions.
Canadian Institute, Proceedings.
Central Chamber of Agriculture, Proceedings.
Chemical Society, Journal.
Cleveland Institution of Engineers, Proceedings.
County of Middlesex Natural History and Science Society, Transactions.
Doubs, Société d'Emulation du, Mémoires.
East India Association, Journal.
Farmers' Club, Journal.
Franklin Institute, Journal.
Gas Institute, Transactions.
Geological Society, Quarterly Journal.
Geologists' Association, Proceedings.
Glasgow Philosophical Society, Proceedings.
India, Geological Survey of, Memoirs, Records and Palæontologia Indica.
Indian Meteorological Memoirs.
Institute of Bankers, Journal.
Institute of Patent Agents, Transactions.
Institution of Civil Engineers, Minutes of Proceedings.
Institution of Civil Engineers of Ireland, Transactions.
Institution of Electrical Engineers, Journal.
Institution of Engineers and Shipbuilders in Scotland, Transactions.
Institution of Mechanical Engineers, Proceedings.
Institution of Naval Architects, Transactions.
Iron and Steel Institute, Journal.
Japan, College of Science, Imperial University, Journal.
Junior Engineering Society, Publications.
Kew Gardens Bulletin.
Linnæan Society, Journal.
Liverpool Literary and Philosophical Society, Proceedings.
Liverpool Polytechnic Society, Journal.
London Association of Foremen Engineers and Draughtsmen, Publications.
London Chamber of Commerce, Journal.
Lyons Société des Sciences Industrielles, Annales.
Manchester Literary and Philosophical Society, Memoirs and Proceedings.
Manitoba Historical and Scientific Society, Transactions.
Mauritius, Société Royale des Arts et des Sciences, Transactions.
Munich, Polytechnischer-Verein, Bayerisches Industrie-und-Gewerbeblatt.
National Indian Association, "The Indian Magazine."
Nederlandsche Maatschappij ter Bevordering van Nijverheid, Tidjschrift.
North-East Coast Institution of Engineers and Shipbuilders, Transactions.
Nova Scotian Institute of Natural Science, Proceedings and Transactions.
Patent-office, The Illustrated Official Journal.
Pharmaceutical Society, Journal and Transactions.
Philadelphia, Academy of Natural Sciences, Proceedings.
————, Engineers' Club of, Proceedings.
Photographic Society of Great Britain, Journal.
Physical Society of London, Proceedings.
Quekett Microscopical Club, Journal.
Royal Agricultural Society, Journal.
Royal Astronomical Society, Memoirs.
Royal Colonial Institute, Proceedings.
Royal Cornwall Polytechnic Society, Annual Report.
Royal Geographical Society, Proceedings and Journal.
Royal Geological Society of Ireland, Journal.
Royal Historical and Archœological Association of Ireland, Journal.
Royal Institute of British Architects, Journal of Proceedings and Transactions.
Royal Institution of Great Britain, Proceedings.
Royal Irish Academy, Transactions and Proceedings.

Royal Meteorological Society, Quarterly Journal.
Royal National Life Boat Institution, "The Life Boat."
Royal Scottish Society of Arts, Transactions.
Royal Society, Philosophical Transactions and Proceedings.
Royal Society of Edinburgh, Transactions and Proceedings.
Royal Statistical Society, Journal.
Royal United Service Institution, Journal.
Schlesische Gesellschaft für vaterländische Cultur, Jahres Bericht.
Société d'Encouragement pour l'Industrie Nationale, Bulletin.
Société Internationale des Electriciens, Bulletin.
Société Nationale d'Acclimatation de France, Bulletin Bimensuel.
Society of Antiquaries, Archæologia and Proceedings.
Society of Biblical Archæology, Transactions and Proceedings.
Society of Chemical Industry, Journal.
Society of Cymmrodorion, Magazine.
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